FIRST DRAFT OF 15 DAY LANGUAGE

September 4, 2003

CHANGES FOR ALL BUILDINGS

ACM IV

U-factor, C-factor, and Thermal Mass Data

NOTE: THIS APPENDIX IS NEW TO THE 2005 DOCUMENTS. IT CONTAINS NEW TABLES FEATURING SOME INFORMATION THAT WAS PREVIOUSLY ADDRESSED IN THE 2001 NACM APPENDIX B AND THE RACM APPENDIX I.

IV.1 Scope and Purpose

IV.1.1 Introduction

~~The data is t~~ This appendix ~~applies to all buildings subject to the Energy Efficiency Standards for residential and nonresidential buildings. S~~ provides standand ~~thermal performance factors (~~U-factors~~) are provided~~ for common construction assemblies used in residential and nonresidential building construction. The values in this appendix ~~must~~ shall be used for all residential and nonresidential compliance calculations: prescriptive ~~system performance~~ (including envelope component and overall envelope approaches), and ~~whole building~~ performance.

The data tables are organized first by roofs, walls, and floors. Within each component type the data is further organized by construction type, beginning with wood framed construction, followed by metal framed construction, concrete and special construction assemblies. The ~~lookup~~ tables ~~allow users to~~ determine the U-factor of a particular construction assembly without calculations.

Each table features a letter/number coordinate system (shaded in gray) that can be used as an identifier for each value, i.e. IV2-A10 indicates Table IV.2, Column A, Row 10. Construction assembly descriptions shall be formatted to specify first the row and then the column. For example, the descriptions of IV1-A17 and IV9-H3 shall be as follows (abbreviations are acceptable):

Wood Framed Attic, Trusses@24 in. OC, R-30 attic insulation, No continuous insulation
Wood Framed Wall, 2x4 @16 in. OC, R-13 cavity insulation, R-7 continuous insulation

If a construction assembly is not adequately represented in the tables below, the permit applicant or the manufacturer of the product may request approval from the CEC for a U-factor(s) representing that assembly. Such approval shall be granted by the CEC Executive Director, after reviewing submittals from the applicant. New constructions that are approved by the Executive Director will be published for use by all compliance documentation authors. ~~Through the exceptional method process.~~

IV.1.2 Adjustments and Application

In the tables below, continuous insulation assumes that the insulation is continuous and uninterrupted by framing~~ed~~, except where noted.

Software used with performance calculations may have input screens where the user may choose a construction by entering the cavity insulation (or insulation penetrated by framing); the continuous insulation; and other factors such as framing spacing. Software used with performance calculations may have input screens where the user may choose a construction by entering the cavity insulation (or insulation penetrated by framing), the continuous insulation, and other factors such as framing spacing. Performance software may interpolate between values in the table. Values used for prescriptive compliance (including envelope component and overall envelope approaches) shall not be interpolated. For prescriptive compliance where the actual insulation level(s) or framing spacing is not the same as any assembly in the table, the U-factor value for the closest R-value of insulation that is lower and/or the closest framing spacing that is lower than the actual values shall be used. For prescriptive compliance, except for metal buildings, where the actual R-value of insulation or the actual framing spacing is lower than any values in the table, the U-factor value for the lowest R-value or for the lowest framing spacing in the table shall be used.~~Interpolation between values in a particular table is allowed; however e~~ Extrapolation beyond the limits of the table is not allowed.

The units of U-factor are Btu/h-ft^2-°F. Units of R-value are h-ft^2-F/Btu at a mean temperature of 75 ºF. The units of heat capacity (HC) are Btu/ft^2-°F.

The U-factor of double walls or other double assemblies may be determined by combining the U-factors from the individual construction assemblies in the tables that make up the double assembly. The following equation shall be used:

$$U_{Combined} = \frac{1}{\frac{1}{U_1} + \frac{1}{U_2} + \ldots + \frac{1}{U_N}}$$

The data in Table IV.14 may be used to modify the U-factors and C-factors from Table IV.12 and Table IV.13 when an additional layer is added to the inside or outside of the mass wall. For exterior insulation finish systems (EIFS) or other insulation only systems, values should be selected from row 26 of Table IV-14. In these cases, the R-value of the layer is equal to the R-value of the insulation. The other choices from this table represent systems typically placed on the inside of mass walls. The following equations calculate the total U-factor or C-factor, where U_{mass} and C_{mass} are selected from Table IV.12 or Table IV.13 and $R_{Outside}$ and R_{Inside} are selected from Table IV-14. $R_{outside}$ is selected from row 26 while R_{inside} is selected from rows 1 through 25.

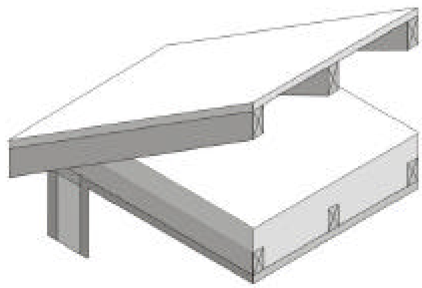
$$U_{Total} = \frac{1}{R_{Outside} + \frac{1}{U_{Mass}} + R_{Inside}} \qquad C_{Total} = \frac{1}{R_{Outside} + \frac{1}{C_{Mass}} + R_{Inside}}$$

If continuous roof insulation is tapered to match the roof slope or other purposes, then an area-weighted average U-factor shall be determined for the roof. Sub-areas shall be defined for each one inch increment of insulation, and the U-factor of each sub-area shall be determined based on the average insulation thickness of that sub-area.

~~If a construction assembly is not adequately represented in the tables below, the permit applicant or the manufacturer of the product may request approval from the CEC~~

IV.2 Roofs and Ceilings

Table IV.1 – Standard U-factors of Wood Framed Attic Roofs (Standard Framing)



Note: Continuous insulation shall be located at the ceiling and be uninterrupted by framing.

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63(PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum board (GP01)of R-0.45, and an interior air film (heat flow up) of R-0.61.

2 x 4 framing is used at the ceiling level. R-13 of attic insulation is assumed between the framing members; above that level, attic insulation is uninterrupted by framing. 7.25% of the attic insulation above the framing members is assumed to be at half depth, due to decreased depth of insulation at the edges. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.

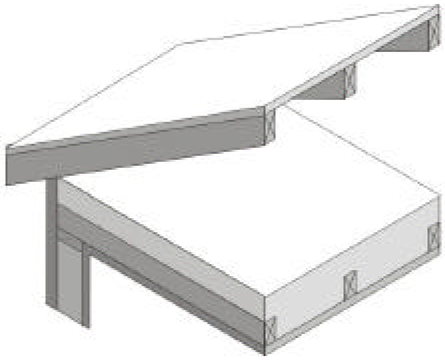
Framing Type (Actual depth)	R-value of ~~Cavity~~ Attic Insul.		Rated R-value of Continuous Insulation										
			R-0	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
			A	B	C	D	E	F	G	H	I	J	K
2 x 4's at 16 in. OC (3.5 in.)	None	1	0.300	0.229	0.186	0.156	0.135	0.119	0.106	0.096	0.087	0.080	0.074
	R-11	2	0.079	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.047	0.045	0.043
	R-13	3	0.071	0.066	0.061	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.040
	R-19	4	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033
	R-22	5	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.030
	R-25	6	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027
	R-30	7	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.025	0.025	0.024
	R-38	8	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.020
	R-49	9	0.020	0.020	0.019	0.019	0.019	0.018	0.018	0.018	0.017	0.017	0.017
	R-60	10	0.017	0.016	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.014	0.014
2 x 4's at 24 in. OC (3.5 in.)	None	11	0.305	0.233	0.188	0.158	0.136	0.120	0.107	0.097	0.088	0.081	0.075
	R-11	12	0.076	0.071	0.066	0.061	0.058	0.055	0.052	0.049	0.047	0.045	0.043
	R-13	13	0.068	0.063	0.059	0.056	0.053	0.050	0.048	0.045	0.043	0.041	0.040
	R-19	14	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.034	0.033	0.032
	R-22	15	0.042	0.040	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029
	R-25	16	0.037	0.036	0.035	0.034	0.032	0.031	0.030	0.030	0.029	0.028	0.027
	R-30	17	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.024
	R-38	18	0.025	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.020
	R-49	19	0.020	0.020	0.019	0.019	0.019	0.018	0.018	0.018	0.017	0.017	0.017
	R-60	20	0.016	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.015	0.014	0.014

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63(PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum board (GP01)of R-0.45, and an interior air film (heat flow up) of R-0.61.~~

~~2 x 4 framing is used at the ceiling level. R-13 of insulation is assumed between the framing members; above that level, insulation is continuous. 7.25% of the continuous insulation above the framing members is assumed to be at half depth, due to decreased depth of insulation at the edges. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.~~

Table IV.2 – Standard U-factors of Wood Framed Attic Roofs (Advanced Framing)



Note: Continuous insulation shall be located at the ceiling and be uninterrupted by framing.

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63(PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum board (GP01)of R-0.45, and an interior air film (heat flow up) of R-0.61.

2 x 4 framing is used at the ceiling level. R-13 of attic insulation is installed between the framing members; above that level, attic insulation is uninterrupted by framing. A full depth of insulation is assumed over the entire ceiling. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.

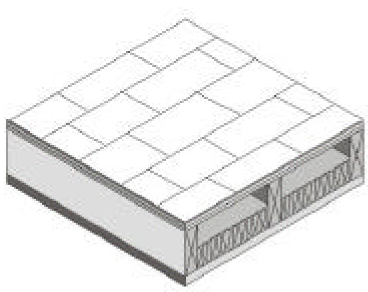
Framing Type (Actual depth)	R-value of Attic Insul.		Rated R-value of Continuous Insulation[1]										
			R-0	**R-1**	**R-2**	**R-3**	**R-4**	**R-5**	**R-6**	**R-7**	**R-8**	**R-9**	**R-10**
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
2 x 4's at 16 in. OC (3.5 in.)	None	**1**	0.300	0.229	0.186	0.156	0.135	0.119	0.106	0.096	0.087	0.080	0.074
	R-11	**2**	0.079	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.047	0.045	0.043
	R-13	**3**	0.071	0.066	0.061	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.040
	R-19	**4**	0.049	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.032
	R-22	**5**	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.032	0.031	0.030	0.029
	R-25	**6**	0.037	0.036	0.035	0.034	0.032	0.031	0.030	0.029	0.029	0.028	0.027
	R-30	**7**	0.031	0.030	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024
	R-38	**8**	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.020	0.020
	R-49	**9**	0.020	0.019	0.019	0.019	0.018	0.018	0.018	0.017	0.017	0.017	0.016
	R-60	**10**	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.014	0.014	0.014	0.014
2 x 4's at 24 in. OC (3.5 in.)	None	**11**	0.305	0.233	0.188	0.158	0.136	0.120	0.107	0.097	0.088	0.081	0.075
	R-11	**12**	0.076	0.071	0.066	0.061	0.058	0.055	0.052	0.049	0.047	0.045	0.043
	R-13	**13**	0.068	0.063	0.059	0.056	0.053	0.050	0.048	0.045	0.043	0.041	0.040
	R-19	**14**	0.048	0.045	0.043	0.041	0.040	0.038	0.037	0.035	0.034	0.033	0.032
	R-22	**15**	0.041	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.029
	R-25	**16**	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027
	R-30	**17**	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.025	0.025	0.024	0.024
	R-38	**18**	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.020	0.020
	R-49	**19**	0.019	0.019	0.019	0.018	0.018	0.018	0.017	0.017	0.017	0.017	0.016
	R-60	**20**	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.014	0.014	0.014	0.014

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63(PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum board (GP01)of R-0.45, and an interior air film (heat flow up) of R-0.61.~~

~~2 x 4 framing is used at the ceiling level. R-13 of insulation is installed between the framing members; above that level, insulation is continuous. A full depth of insulation is assumed over the entire ceiling. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.~~

Table IV.3 – Standard U-factors of Wood Framed Rafter Roofs



Source: ASHRAE parallel heat flow calculations, ASHRAE Fundamentals Handbook

Notes:

[1] Higher density fiberglass batt: R-30 in 2 x 10 rafter cavity is the 8.5" thick batt; R-38 in 2 x 12 rafter cavity is the 10.5" thick batt.

[2] Continuous insulation shall be located at the ceiling or at the roof and be uninterrupted by framing.

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), continuous insulation (optional), the insulation / framing layer with an air space of R-0.76 or R-0.80, 1/2" gypsum of R-0.45plywood (PW03), and an interior air film (heat flow up diagonally) of R-0.62. Note: The continuous insulation may also be located at the ceiling, between the drywall and the framing.

Framing Type (Actual depth)	R-value of Cavity Insul.		Rated R-value of Continuous Insulation[2]										
			R-0	**R-1**	**R-2**	**R-3**	**R-4**	**R-5**	**R-6**	**R-7**	**R-8**	**R-9**	**R-10**
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
2x4's at 16 in. oc (5.5 in.)	None	**1**	0.297	0.227	0.184	0.155	0.134	0.118	0.105	0.095	0.087	0.080	0.074
	R-11	**2**	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043
	R-13	**3**	0.069	0.064	0.060	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040
	R-15	**4**	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038
2x8's at 16 in. oc	R-19	**5**	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033
	R-21	**6**	0.048	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.031
2x10's at 16 in. oc	R-22	**7**	0.044	0.042	0.041	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030
	R-25	**8**	0.041	0.039	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028
	R-30 [1]	**9**	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.026
2x12's at 16 in. oc	R-30	**10**	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025
	R-38[1]	**11**	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.022	0.022
2x14's at 16 in. oc	R-38	**12**	0.028	0.027	0.027	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022
2x4's at 16 in. oc (5.5 in.)	None	**13**	0.237	0.191	0.160	0.138	0.121	0.108	0.097	0.089	0.081	0.075	0.070
	R-11	**14**	0.075	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.046	0.044	0.042
	R-13	**15**	0.067	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.040
	R-15	**16**	0.060	0.057	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.038	0.037
2x8's at 16 in. oc	R-19	**17**	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033
	R-21	**18**	0.046	0.044	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031
2x10's at 16 in. oc	R-22	**19**	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.030
	R-25	**20**	0.039	0.038	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.028
	R-30[1]	**21**	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.025	0.025
2x12's at 16 in. oc	R-30	**22**	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025	0.025
	R-38 [1]	**23**	0.028	0.027	0.026	0.025	0.025	0.024	0.023	0.023	0.022	0.022	0.021
2x14's at 16 in. oc	R-38	**24**	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.022	0.022	0.021	0.021

~~**Source:** Based on ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook~~

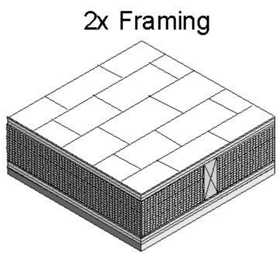
~~**Notes:**~~

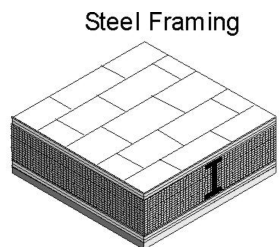
~~[1] Higher density fiberglass batt: R-30 in 2 x 10 rafter cavity is the 8.5" thick batt; R-38 in 2 x 12 rafter cavity is the 10.5" thick batt.~~

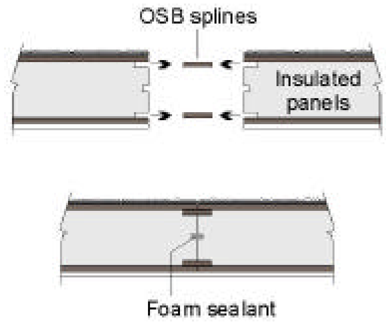
~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), continuous insulation (optional), the insulation / framing layer with an air space of R-0.76 or R-0.80, 1/2" gypsum of R-0.45plywood (PW03), and an interior air film (heat flow up diagonally) of R-0.62. Note: The continuous insulation may also be located at the ceiling, between the drywall and the framing.~~

Table IV.4 – Standard U-factors of Structurally Insulated Panels (SIPS) Roof/Ceilings







Insulation R-value	Framing or Spline Spacing		2x Wood Framing	Steel Framing	OSB- Spline
			A	B	C
R-14	48 in. o.c.	1	0.064	0.075	n. a.
R-22	48 in. o.c.	2	0.043	0.057	0.041
R-28	48 in. o.c.	3	0.034	0.047	0.0318
R-36	48 in. o.c.	4	0.029	0.043	0.0256
R-22	96 in o.c.	5	0.041	n. a.	0.040
R-28	96 in o.c.	6	0.033	n. a.	0.0318
R-36	96 in o.c.	7	0.026	n. a.	0.0255

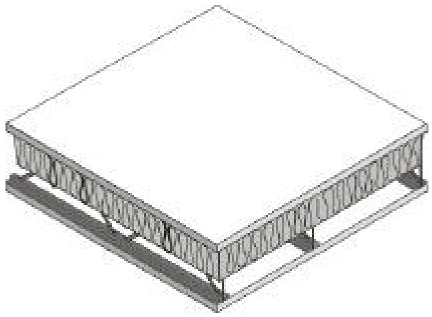
Source: ASHRAE Parallel Path Heat Flow Calculation for wood framing and OSB splines, 2001 ASHRAE Fundamentals Handbook. Assemblys with metal framing are calculated using the ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), 7/16" of OSB of R-0.69, the insulation / framing layer, 7/16" of OSB, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film (heat flow up diagonally) of R-0.62.

The 2x spline refers to a wood 2x member used to join panels together. The 7/16" OSB spline refers to a 7/16" double-spline used to join two panels together. OSB splines with other thicknesses shall also use this tabulated value.

Table IV.5 – Standard U-factors of Metal Framed Rafter Roofs with Wood Deck



Source: ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook

Notes:

[1] Higher density fiberglass batt: R-30 in 2 x 10 rafter cavity is the 8.5" thick batt; R-38 in 2 x 12 rafter cavity is the 10.5" thick batt.

[2] Continuous insulation shall be located above the deck and uninterrupted by framing.

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), the insulation / framing layer, continuous insulation, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film (heat flow up diagonally) of R-0.62.

Spacing	Framing Type (Actual depth	R-Value of Insulation Penetrated by Framing		Rated R-value of Continuous Insulation[2]										
				R-0	**R-2**	**R-4**	**R-6**	**R-8**	**R-10**	**R-12**	**R-15**	**R-20**	**R-25**	**R-30**
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
16 in. OC	2 x 6	None	**1**	0.336	0.201	0.143	0.111	0.091	0.077	0.067	0.056	0.044	0.036	0.030
		R-11	**2**	0.121	0.097	0.081	0.070	0.061	0.055	0.049	0.043	0.035	0.030	0.026
		R-13	**3**	0.111	0.091	0.077	0.067	0.059	0.053	0.048	0.042	0.034	0.029	0.026
	2 x 8	R-19	**4**	0.108	0.088	0.075	0.065	0.058	0.052	0.047	0.041	0.034	0.029	0.025
		R-21	**5**	0.102	0.085	0.073	0.063	0.056	0.051	0.046	0.040	0.034	0.029	0.025
	2 x 10	R-25	**6**	0.104	0.086	0.074	0.064	0.057	0.051	0.046	0.041	0.034	0.029	0.025
		R-30 [1]	**7**	0.094	0.079	0.068	0.060	0.054	0.048	0.044	0.039	0.033	0.028	0.025
	2 x 12	R-30	**8**	0.073	0.063	0.056	0.051	0.046	0.042	0.039	0.035	0.030	0.026	0.023
		R-38 [1]	**9**	0.064	0.057	0.051	0.046	0.042	0.039	0.036	0.033	0.028	0.025	0.022
	2 x 14	R-38	**10**	0.063	0.056	0.050	0.046	0.042	0.039	0.036	0.032	0.028	0.024	0.022
24 in. OC	2 x 6	None	**11**	0.333	0.200	0.143	0.111	0.091	0.077	0.067	0.056	0.043	0.036	0.030
		R-11	**12**	0.118	0.095	0.080	0.069	0.061	0.054	0.049	0.043	0.035	0.030	0.026
		R-13	**13**	0.108	0.089	0.075	0.065	0.058	0.052	0.047	0.041	0.034	0.029	0.025
	2 x 8	R-19	**14**	0.108	0.088	0.075	0.065	0.058	0.052	0.047	0.041	0.034	0.029	0.025
		R-21	**15**	0.102	0.085	0.073	0.063	0.056	0.051	0.046	0.040	0.034	0.029	0.025
	2 x 10	R-25	**16**	0.099	0.083	0.071	0.062	0.055	0.050	0.045	0.040	0.033	0.028	0.025
		R-30 [1]	**17**	0.088	0.075	0.065	0.058	0.052	0.047	0.043	0.038	0.032	0.028	0.024
	2 x 12	R-30	**18**	0.070	0.061	0.054	0.049	0.045	0.041	0.038	0.034	0.029	0.025	0.023
		R-38 [1]	**19**	0.061	0.055	0.049	0.045	0.041	0.038	0.035	0.032	0.028	0.024	0.022
	2 x 14	R-38	**20**	0.060	0.053	0.048	0.044	0.040	0.037	0.035	0.032	0.027	0.024	0.021

~~**Source:** ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook~~

~~**Notes:**~~

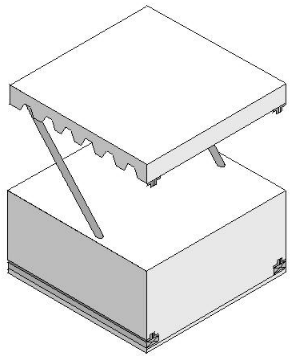
~~[1] Higher density fiberglass batt: R-30 in 2 x 10 rafter cavity is the 8.5" thick batt; R-38 in 2 x 12 rafter cavity is the 10.5" thick batt.~~

~~[2] If credit is requested for more than 1.5" of continuous rigid insulation, at least one third of the rigid insulation (up to 2 inches) should be applied to the underside of the rafters.~~

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), the insulation / framing layer, continuous insulation, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film (heat flow up diagonally) of R-0.62.~~

Table IV.6 – Standard U-factors of Metal Framed Roofs with Attics



Source: ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook

Assumptions:

These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film (heat flow up) of R-0.61.

2 x 4 framing is used at the ceiling level. R-13 of insulation is installed between the framing members; above that level, insulation is continuous. Insulation is assumed to be full depth over the entire ceiling. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.

				Rated R-value of Continuous Insulation										
				R-0	R-2	R-4	R-6	R-8	R-10	R-12	R-15	R-20	R-25	R-30
Spacing	Framing Type (Actual depth)	Cavity Insulation R-Value:		A	B	C	D	E	F	G	H	I	J	K
16 in. OC	2 x 4	None	1	0.316	0.194	0.140	0.109	0.090	0.076	0.066	0.055	0.043	0.036	0.030
	(3.65 in.)	R-11	2	0.152	0.117	0.095	0.080	0.069	0.060	0.054	0.046	0.038	0.032	0.027
		R-13	3	0.147	0.114	0.093	0.078	0.068	0.060	0.053	0.046	0.037	0.031	0.027
		R-19	4	0.078	0.068	0.060	0.053	0.048	0.044	0.040	0.036	0.030	0.026	0.023
		R-22	5	0.063	0.056	0.051	0.046	0.042	0.039	0.036	0.032	0.028	0.025	0.022
		R-25	6	0.053	0.048	0.044	0.040	0.037	0.035	0.032	0.030	0.026	0.023	0.020
		R-30	7	0.042	0.039	0.036	0.034	0.031	0.030	0.028	0.026	0.023	0.020	0.019
		R-38	8	0.031	0.030	0.028	0.026	0.025	0.024	0.023	0.021	0.019	0.018	0.016
		R-49	9	0.023	0.022	0.021	0.020	0.020	0.019	0.018	0.017	0.016	0.015	0.014
		R-60	10	0.019	0.018	0.017	0.017	0.016	0.016	0.015	0.015	0.014	0.013	0.012
24 in. OC	2 x 4	None	11	0.316	0.194	0.140	0.109	0.090	0.076	0.066	0.055	0.043	0.036	0.030
	(3.65 in.)	R-11	12	0.134	0.106	0.087	0.074	0.065	0.057	0.051	0.045	0.036	0.031	0.027
		R-13	13	0.130	0.103	0.085	0.073	0.064	0.056	0.051	0.044	0.036	0.031	0.027
		R-19	14	0.073	0.064	0.056	0.051	0.046	0.042	0.039	0.035	0.030	0.026	0.023
		R-22	15	0.060	0.053	0.048	0.044	0.040	0.037	0.035	0.032	0.027	0.024	0.021
		R-25	16	0.051	0.046	0.042	0.039	0.036	0.034	0.032	0.029	0.025	0.022	0.020
		R-30	17	0.040	0.037	0.035	0.033	0.031	0.029	0.027	0.025	0.022	0.020	0.018
		R-38	18	0.031	0.029	0.027	0.026	0.025	0.023	0.022	0.021	0.019	0.017	0.016
		R-49	19	0.023	0.022	0.021	0.020	0.019	0.019	0.018	0.017	0.016	0.015	0.014
		R-60	20	0.018	0.018	0.017	0.016	0.016	0.015	0.015	0.014	0.013	0.013	0.012

~~**Source:** ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook~~

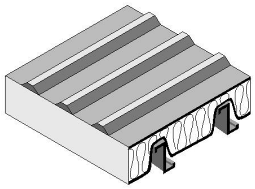
~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44(AR02), building paper of R-0.06(BP01), ½" of plywood of R-0.63plywood (PW03), the attic air space (greater than 3.5") of R-0.80, the insulation / framing layer, continuous insulation (if any) 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film (heat flow up) of R-0.61.~~

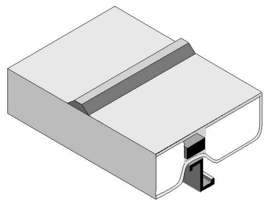
~~2 x 4 framing is used at the ceiling level. R-13 of insulation is installed between the framing members; above that level, insulation is continuous. Insulation is assumed to be full depth over the entire ceiling. Any rigid continuous insulation is applied under the ceiling framing and above the gypsum board.~~

Table IV.7 – Standard U-factors for Metal Building Roofs

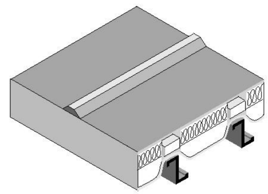
Screw-Down, No Thermal Blocks



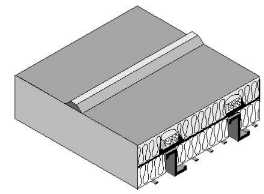
Single Layer, Thermal Blocks



Double Layer, Thermal Blocks



Filled Cavity, Thermal Blocks



			Rated R-value of Continuous Insulation									
	R-Value of Insulation		R-0	R-4	R-6	R-8	R-10	R-12	R-15	R-20	R-25	R-30
Insulation System			**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Screw Down Roofs (no Thermal Blocks)[2]	None	**1**	1.280	0.209	0.147	0.114	0.093	0.078	0.063	0.048	0.039	0.032
	R-10	**2**	0.153	0.095	0.080	0.069	0.060	0.054	0.046	0.038	0.032	0.027
	R-11	**3**	0.139	0.089	0.076	0.066	0.058	0.052	0.045	0.037	0.031	0.027
	R-13	**4**	0.130	0.086	0.073	0.064	0.057	0.051	0.044	0.036	0.031	0.027
	R-19	**5**	0.098	0.070	0.062	0.055	0.049	0.045	0.040	0.033	0.028	0.025
Standing Seam Roof with Single Layer of Insulation Draped over Purlins and Compressed. Thermal blocks at supports.[2]	R-10	**6**	0.097	0.070	0.061	0.055	0.049	0.045	0.040	0.033	0.028	0.025
	R-11	**7**	0.092	0.067	0.059	0.053	0.048	0.044	0.039	0.032	0.028	0.024
	R-13	**8**	0.083	0.062	0.055	0.050	0.045	0.042	0.037	0.031	0.027	0.024
	R-19	**9**	0.065	0.052	0.047	0.043	0.039	0.037	0.033	0.028	0.025	0.022
Standing Seam Roof with Double Layer of Insulation.[4] Thermal blocks at supports.[2]	R-10 + R-10	**10**	0.063	0.050	0.046	0.042	0.039	0.036	0.032	0.028	0.024	0.022
	R-10 + R-11	**11**	0.061	0.049	0.045	0.041	0.038	0.035	0.032	0.027	0.024	0.022
	R-11 + R-11	**12**	0.060	0.048	0.044	0.041	0.038	0.035	0.032	0.027	0.024	0.021
	R-10 + R-13	**13**	0.058	0.047	0.043	0.040	0.037	0.034	0.031	0.027	0.024	0.021
	R-11 + R-13	**14**	0.057	0.046	0.042	0.039	0.036	0.034	0.031	0.027	0.024	0.021
	R-13 + R-13	**15**	0.055	0.045	0.041	0.038	0.035	0.033	0.030	0.026	0.023	0.021
	R-10 + R-19	**16**	0.052	0.043	0.040	0.037	0.034	0.032	0.029	0.025	0.023	0.020
	R-11 + R-19	**17**	0.051	0.042	0.039	0.036	0.034	0.032	0.029	0.025	0.022	0.020
	R-13 + R-19	**17**	0.049	0.041	0.038	0.035	0.033	0.031	0.028	0.025	0.022	0.020
	R-19 + R-19	**18**	0.046	0.039	0.036	0.034	0.032	0.030	0.027	0.024	0.021	0.019
Filled Cavity with Thermal Blocks[2,5]	R19 + R-10	**19**	0.041	0.035	0.033	0.031	0.029	0.027	0.025	0.023	0.020	0.018

Source: ASHRAE Standard 90.1-2001; NAIMA Compliance for Metal Buildings 1997

Notes:

1 A roof must have metal purlins no closer than 4 ft on center to use this table. If the roof deck is attached to the purlins more frequently than 12 in oc, 0.008 must be added to the U-factors in this table.

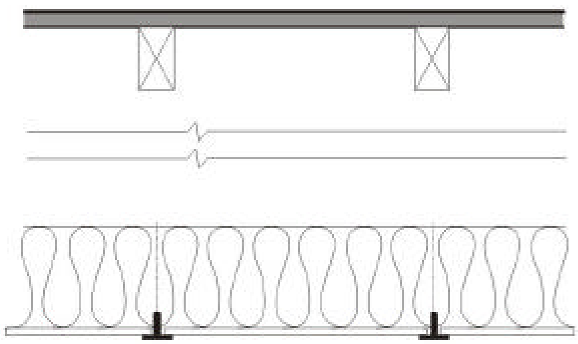
2 Thermal blocks are an R-5 of rigid insulation, which extends 1" beyond the width of the purlin on each side.

3 Multiple R-values are listed in order from outside to inside.

4 First layer draped over the purlins, second layer is laid on top of the first layer, parallel to the purlins.

5 First layer is parallel to the purlins, and supported by a system; second layer is laid on top of the purlins.

Table IV.8 – Suspended Ceiling with Removable Ceiling Panels



Source: Parallel Path Calculations, ASHRAE Fundamentals Handbook, 2001

Notes:

This method of calculating the effect of insulation placed on top of a suspended ceiling with removable ceiling panels shall be used only when there are conditioned spaces with a combined floor area no greater than 2,000 square feet in an otherwise unconditioned building, and when the average height of the space between the ceiling and the roof over these spaces is greater than 12 feet.

Assumptions

These calculations assume an exterior air film of R-0.17, built-up roof of R-0.33(BR01), plywood of R-0.94(PW05), a twelve foot air space of R-0.80, the insulation (for the insulated portion), removable ceiling panel of R-0.50 and an interior air film (heat flow up) of R-0.61. 75% of the ceiling is assumed to be covered by insulation and the remainder is not insulated. The uninsulated portion includes lighting fixtures and areas where the insulation is not continuous. An adder of 0.005 is added to the resulting U-factor to account for infiltration through the suspended ceiling and lighting fixtures.

		U-factor
R-value of Insulation Over Suspended Ceiling		**A**
None	**1**	0.304
7	**2**	0.152
11	**3**	0.132
13	**4**	0.126
19	**5**	0.113
21	**6**	0.110
22	**7**	0.109
30	**8**	0.102
38	**9**	0.098
49	**10**	0.094
60	**11**	0.092

~~**Source**: Parallel Path Calculations, ASHRAE Fundamentals Handbook, 2001~~

~~**Notes**:~~

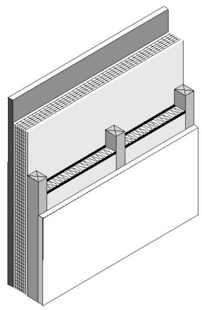
~~This method of calculating the effect of insulation placed on top of a suspended ceiling with removable ceiling panels shall be used only when there are conditioned spaces with a combined floor area no greater than 2,000 square feet in an otherwise unconditioned building, and when the average height of the space between the ceiling and the roof over these spaces is greater than 12 feet.~~

~~**Assumptions**~~

~~These calculations assume an exterior air film of R-0.17, built-up roof of R-0.33(BR01), plywood of R-0.94(PW05), a twelve foot air space of R-0.80, the insulation (for the insulated portion), removable ceiling panel of R-0.50 and an interior air film (heat flow up) of R-0.61. 75% of the ceiling is assumed to be covered by insulation and the remainder is not insulated. The uninsulated portion includes lighting fixtures and areas where the insulation is not continuous. An adder of 0.005 is added to the resulting U-factor to account for infiltration through the suspended ceiling and lighting fixtures.~~

IV.3 Walls

Table IV.9 – Standard U-factors of Wood Framed Walls



Source: ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook

Notes:

[1] Higher density fiberglass batt: R-30 in 2 x 10 wall cavity is the 8.5" thick batt; R-38 in 2 x 12 wall cavity is the 10.5" thick batt.

Assumptions: These calculations assume an exterior air film of R-0.17, a 7/8" layer of stucco of R-0.18, building paper of R-0.06(BP01), continuous insulation (if any), the cavity insulation / framing layer, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film 0.68. The framing factor is assumed to be 25% for 16 in. stud spacing and 22% for 24 in. spacing.

OVERALL U-FACTOR FOR ASSEMBLY

				Rated R-value of Continuous Insulation										
Spacing	Framing Type (Actual depth)	Cavity Insulation R-Value:		R-0	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
				A	B	C	D	E	F	G	H	I	J	K
16 in. OC	2 x 4	None	1	0.356	0.259	0.204	0.169	0.144	0.126	0.111	0.100	0.091	0.083	0.077
	(3.5 in.)	R-11	2	0.110	0.097	0.087	0.079	0.073	0.068	0.063	0.059	0.056	0.053	0.050
		R-13	3	0.102	0.090	0.081	0.074	0.068	0.063	0.059	0.056	0.052	0.050	0.047
		R-15	4	0.095	0.084	0.076	0.070	0.064	0.060	0.056	0.053	0.050	0.047	0.045
	2 x 6	R-19 [1]	5	0.074	0.068	0.063	0.058	0.055	0.051	0.049	0.046	0.044	0.042	0.040
	(5.5 in.)	R-21	6	0.069	0.063	0.058	0.054	0.051	0.048	0.046	0.043	0.041	0.039	0.038
	2 x 8	R-19	7	0.065	0.061	0.057	0.053	0.050	0.048	0.045	0.043	0.041	0.039	0.038
	(7.25 in.)	R-22	8	0.061	0.056	0.053	0.050	0.047	0.045	0.042	0.040	0.039	0.037	0.036
		R-25	9	0.057	0.053	0.050	0.047	0.044	0.042	0.040	0.038	0.037	0.035	0.034
		R-30 [1]	10	0.056	0.052	0.049	0.046	0.043	0.041	0.039	0.038	0.036	0.035	0.033
	2 x 10	R-30	11	0.047	0.044	0.042	0.040	0.038	0.036	0.035	0.034	0.032	0.031	0.030
	(9.25 in.)	R-38 [1]	12	0.046	0.043	0.041	0.039	0.037	0.035	0.034	0.033	0.031	0.030	0.029
24 in. OC	2 x 4	None	13	0.362	0.263	0.207	0.171	0.145	0.127	0.112	0.101	0.092	0.084	0.077
	(3.5 in.)	R-11	14	0.106	0.094	0.085	0.078	0.072	0.066	0.062	0.058	0.055	0.052	0.049
		R-13	15	0.098	0.087	0.079	0.072	0.067	0.062	0.058	0.055	0.052	0.049	0.046
		R-15	16	0.091	0.081	0.073	0.067	0.062	0.058	0.055	0.051	0.049	0.046	0.044
	2 x 6	R-19	17	0.071	0.066	0.061	0.057	0.053	0.050	0.047	0.045	0.043	0.041	0.039
	(5.5 in.)	R-21	18	0.066	0.061	0.056	0.053	0.049	0.047	0.044	0.042	0.040	0.038	0.037
	2 x 8	R-19	19	0.062	0.057	0.054	0.051	0.048	0.045	0.043	0.041	0.039	0.038	0.036
	(7.25 in.)	R-22	20	0.057	0.053	0.050	0.047	0.045	0.042	0.040	0.039	0.037	0.035	0.034
		R-25	21	0.053	0.050	0.047	0.044	0.042	0.040	0.038	0.036	0.035	0.034	0.032
		R-30 [1]	22	0.052	0.049	0.046	0.043	0.041	0.039	0.037	0.036	0.034	0.033	0.032
	2 x 10	R-30	23	0.044	0.042	0.040	0.038	0.036	0.035	0.033	0.032	0.031	0.030	0.029
	(9.25 in.)	R-38 [1]	24	0.043	0.041	0.038	0.037	0.035	0.033	0.032	0.031	0.030	0.029	0.028

~~**Source:** ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook~~

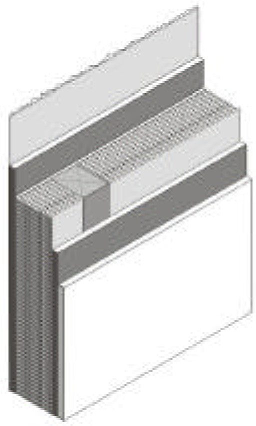
~~**Notes:**~~

~~[1] Higher density fiberglass batt: R-30 in 2 x 10 wall cavity is the 8.5" thick batt; R-38 in 2 x 12 wall cavity is the 10.5" thick batt.~~

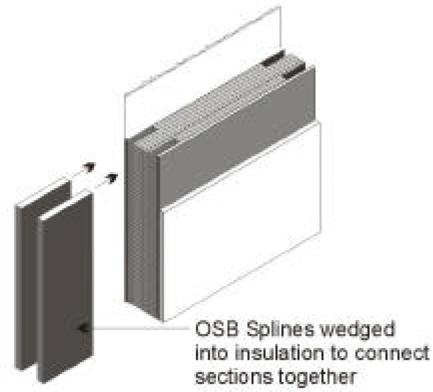
~~**Assumptions**: These calculations assume an exterior air film of R-0.17, a 7/8" layer of stucco of R-0.18, building paper of R-0.06(BP01), continuous insulation (if any), the cavity insulation / framing layer, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film 0.68. The framing factor is assumed to be 25% for 16 in. stud spacing and 22% for 24 in. spacing.~~

Table IV.10 – Standard U-factors of Structurally Insulated Wall Panels (SIPS)

Wood Spacers



OSB Spline



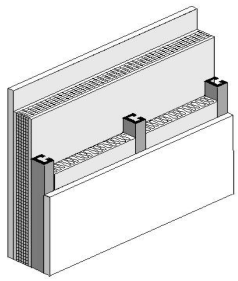
Insulation R-R-	Framing or Spline Spacing		Wood Spacers A	OSB Spline B
R-14	48 in. o.c.	1	0.070	0.065
R-22	48 in. o.c.	2	0.054	0.048
R-26	48 in o.c.	3	0.047	n. a.
R-28	48 in o.c.	4	0.039	0.040
R-36	48 in o.c.	5	0.032	0.029
R-40	48 in o.c.	6	0.033	n. a.
R-44	48 in o.c.	7	0.027	0.0246

Source: Parallel Path Heat Flow Calculation, ASHRAE Fundamentals Handbook

Assumptions

These calculations assume an exterior air film of R-0.17, a 7/8" layer of stucco of R-0.18, building paper of R-0.06(BP01), 7/16" of OSB, insulation (as specified), 7/16" of OSB, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film 0.68. A framing factor of 13% is assumed for wood spacers and 7% for the OSB spline. Framing includes the sill plate, the header and framing around windows and doors.

Table IV.11 – Standard U-factors of Metal Framed Walls



Source: ASHRAE Zone Method Calculation, ASHRAE Fundamentals Handbook

Notes:

1 Batt insulation is compressed

For wall constructions that use exterior metal sheathing in direct with the metal studs, constructions must be selected from the "None" row for cavity insulation, regardless of the insulation installed in the cavity.

Assumptions:

These calculations assume an exterior air film of R-0.17, a 7/8" layer of stucco of R-0.18, building paper of R-0.06(BP01), continuous insulation (if any), the insulation / framing layer, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film 0.68. The framing factor is assumed to be 25% for 16 in. stud spacing and 22% for 24 in. spacing.

				Rated R-value of Continuous Insulation										
				R-0	**R-2**	**R-4**	**R-6**	**R-8**	**R-10**	**R-12**	**R-15**	**R-20**	**R-25**	**R-30**
Spacing	**Framing Type (Actual depth)**	**Cavity Insulation R-Value:**		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
16 in. OC	2 x 4	None	**1**	0.472	0.243	0.163	0.123	0.099	0.083	0.071	0.058	0.045	0.037	0.031
	(3.65 in.)	R-11	**2**	0.268	0.174	0.129	0.103	0.085	0.073	0.064	0.053	0.042	0.035	0.030
		R-13	**3**	0.261	0.171	0.128	0.102	0.085	0.072	0.063	0.053	0.042	0.035	0.030
		R-15	**4**	0.256	0.169	0.126	0.101	0.084	0.072	0.063	0.053	0.042	0.035	0.029
	2 x 6	R-19[1]	**5**	0.220	0.153	0.117	0.095	0.080	0.069	0.060	0.051	0.041	0.034	0.029
		R-21	**6**	0.218	0.152	0.116	0.094	0.079	0.069	0.060	0.051	0.041	0.034	0.029
	2 x 8	R-19	**7**	0.189	0.137	0.108	0.089	0.075	0.065	0.058	0.049	0.040	0.033	0.028
		R-22	**8**	0.185	0.135	0.106	0.088	0.075	0.065	0.057	0.049	0.039	0.033	0.028
		R-25	**9**	0.183	0.134	0.106	0.087	0.074	0.065	0.057	0.049	0.039	0.033	0.028
		R-30[1]	**10**	0.182	0.133	0.105	0.087	0.074	0.065	0.057	0.049	0.039	0.033	0.028
	2 x 10	R-30	**11**	0.164	0.123	0.099	0.083	0.071	0.062	0.055	0.047	0.038	0.032	0.028
		R-38[1]	**12**	0.162	0.122	0.098	0.082	0.071	0.062	0.055	0.047	0.038	0.032	0.028
24 in. OC	2 x 4	None	**13**	0.461	0.240	0.162	0.122	0.098	0.082	0.071	0.058	0.045	0.037	0.031
	(3.65 in.)	R-11	**14**	0.230	0.158	0.120	0.097	0.081	0.070	0.061	0.052	0.041	0.034	0.029
		R-13	**15**	0.222	0.154	0.118	0.095	0.080	0.069	0.061	0.051	0.041	0.034	0.029
		R-15	**16**	0.217	0.151	0.116	0.094	0.079	0.068	0.060	0.051	0.041	0.034	0.029
	2 x 6	R-19[1]	**17**	0.186	0.136	0.107	0.088	0.075	0.065	0.058	0.049	0.039	0.033	0.028
		R-21	**18**	0.181	0.133	0.105	0.087	0.074	0.064	0.057	0.049	0.039	0.033	0.028
	2 x 8	R-19	**19**	0.160	0.121	0.098	0.082	0.070	0.062	0.055	0.047	0.038	0.032	0.028
		R-22	**20**	0.156	0.119	0.096	0.081	0.069	0.061	0.054	0.047	0.038	0.032	0.027
		R-25	**21**	0.154	0.118	0.095	0.080	0.069	0.061	0.054	0.047	0.038	0.032	0.027
		R-30[1]	**22**	0.153	0.117	0.095	0.080	0.069	0.060	0.054	0.046	0.038	0.032	0.027
	2 x 10	R-30	**23**	0.137	0.108	0.089	0.075	0.065	0.058	0.052	0.045	0.037	0.031	0.027
		R-38[1]	**24**	0.136	0.107	0.088	0.075	0.065	0.058	0.052	0.045	0.037	0.031	0.027

~~**Source**: ASHRAE Zone Method Calculation, ASHRAE Fundamentals Handbook~~

~~**Notes**:~~

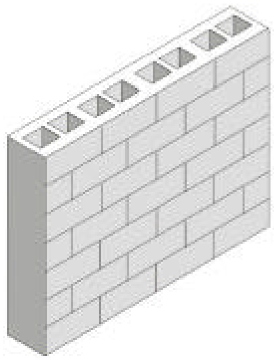
~~[1] Batt insulation is compressed~~

~~For wall constructions that use exterior metal sheathing in direct with the metal studs, constructions must be selected from the "None" row for cavity insulation, regardless of the insulation installed in the cavity.~~

~~**Assumptions**:~~

~~These calculations assume an exterior air film of R-0.17, a 7/8" layer of stucco of R-0.18, building paper of R-0.06(BP01), continuous insulation (if any), the insulation / framing layer, 1/2" gypsum of R-0.45gypsum board (GP01), and an interior air film 0.68. The framing factor is assumed to be 25% for 16 in. stud spacing and 22% for 24 in. spacing.~~

Table IV.12 – Properties of Hollow Unit Masonry Walls



Source: Energy Calculations and Data, CMACN, 1986, Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Notes:

LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90, Calculated at 105 PCF density

MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90, Calculated at 115 PCF density

NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90, Calculated at 125 PCF density

Clay Unit is a Hollow Clay Unit per ASTM C 652, Calculated at 130 PCF density. Values include air films on inner and outer surfaces. Grouted Cells at 32" X 48" in Partly Grouted Walls

						Partly Grouted with Ungrouted Cells							
		Solid Grout				Empty				Insulated			
Type		**A**				**B**				**C**			
	1	U-factor	C-factor	Ru	HC	U-factor	C-factor	Ru	HC	U-factor	C-factor	Ru	HC
12" LW CMU	**2**	0.51	0.90	2.0	23	0.43	0.68	2.3	14.8	0.30	0.40	3.3	14.8
MW CMU	**3**	0.54	1.00	1.9	23.9	0.46	0.76	2.2	15.6	0.33	0.46	3.0	15.6
NW CMU	**4**	0.57	1.11	1.8	24.8	0.49	0.84	2.0	16.5	0.36	0.52	2.8	16.5
10" LW CMU	**5**	0.55	1.03	1.8	18.9	0.46	0.76	2.2	12.6	0.34	0.48	2.9	12.6
MW CMU	**6**	0.59	1.18	1.7	19.7	0.49	0.84	2.1	13.4	0.37	0.54	2.7	13.4
NW CMU	**7**	0.62	1.31	1.6	20.5	0.52	0.93	1.9	14.2	0.41	0.63	2.4	14.2
8" LW CMU	**8**	0.62	1.31	1.6	15.1	0.50	0.87	2.0	9.9	0.37	0.54	2.7	9.9
MW CMU	**9**	0.65	1.45	1.5	15.7	0.53	0.96	1.9	10.5	0.41	0.63	2.4	10.5
NW CMU	**10**	0.69	1.67	1.4	16.3	0.56	1.07	1.8	11.1	0.44	0.70	2.3	11.1
Clay Unit	**11**	0.57	1.11	1.8	15.1	0.47	0.78	2.1	11.4	0.39	0.58	2.6	11.4
6" LW CMU	**12**	0.68	1.61	1.5	10.9	0.54	1.00	1.9	7.9	0.44	0.70	2.3	7.9
MW CMU	**13**	0.72	1.86	1.4	11.4	0.58	1.14	1.7	8.4	0.48	0.81	2.1	8.4
NW CMU	**14**	0.76	2.15	1.3	11.9	0.61	1.27	1.6	8.9	0.52	0.93	1.9	8.9
Clay Unit	**15**	0.65	1.45	1.5	11.1	0.52	0.93	1.9	8.6	0.45	0.73	2.2	8.6

~~**Source**: Energy Calculations and Data, CMACN, 1986, Berkeley Solar Group; Concrete Masonry Association of California and Nevada~~

~~**Notes**:~~

~~LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90, Calculated at 105 PCF density~~

~~MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90, Calculated at 115 PCF density~~

~~NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90, Calculated at 125 PCF density~~

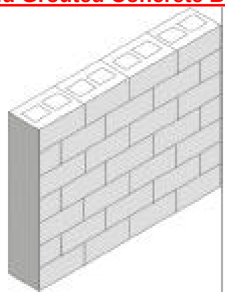
~~Clay Unit is a Hollow Clay Unit per ASTM C 652, Calculated at 130 PCF density~~

~~Values include air films on inner and outer surfaces.~~

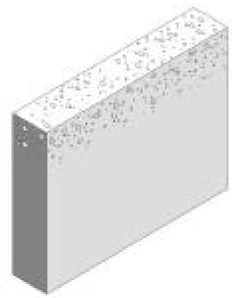
~~Grouted Cells at 32" X 48" in Partly Grouted Walls~~

Table IV.13 – Properties of Solid Unit Masonry and Solid Concrete Walls

Solid Grouted Concrete Block



Concrete



Type	Property		3	4	5	6	7	8	9	10	11	12
			Wall Thickness, inches									
			A	B	C	D	E	F	G	H	I	J
LW CMU	U-Factor	1	na	0.71	0.64	na	na	na	na	na	na	na
	C-Factor		na	1.79	1.40	na	na	na	na	na	na	na
	Ru		na	1.4	1.6	na	na	na	na	na	na	na
	HC		na	7.00	8.75	na	na	na	na	na	na	na
MW CMU	U-Factor	2	na	0.76	0.70	na	na	na	na	na	na	na
	C-Factor		na	2.15	1.73	na	na	na	na	na	na	na
	Ru		na	1.3	1.4	na	na	na	na	na	na	na
	HC		na	7.67	9.58	na	na	na	na	na	na	na
NW CMU	U-Factor	3	0.89	0.82	0.76	na	na	na	na	na	na	na
	C-Factor		3.66	2.71	2.15	na	na	na	na	na	na	na
	Ru		1.1	1.2	1.3	na	na	na	na	na	na	na
	HC		6.25	8.33	10.42	na	na	na	na	na	na	na
Clay Brick	U-Factor	4	0.80	0.72	0.66	na	na	na	na	na	na	na
	C-Factor		2.50	1.86	1.50	na	na	na	na	na	na	na
	Ru		1.3	1.4	1.5	na	na	na	na	na	na	na
	HC		6.30	8.40	10.43	na	na	na	na	na	na	na
Concrete	U-Factor	5	0.96	0.91	0.86	0.82	0.78	0.74	0.71	0.68	0.65	0.63
	C-Factor		5.22	4.02	3.20	2.71	2.31	1.99	1.79	1.61	1.45	1.36
	Ru		1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6
	HC		7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80

Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Notes:

LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 105 PCF density

MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 115 PCF density

NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 125 PCF density

Clay Brick is a Clay Unit per ASTM C 62, Calculated at 130 PCF density

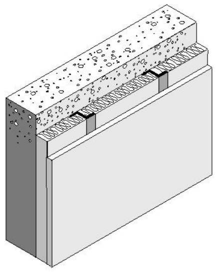
Concrete is structural poured or precast concrete, Calculated at 144 PCF density

Calculations based on Energy Calculations and Data, CMACN, 1986

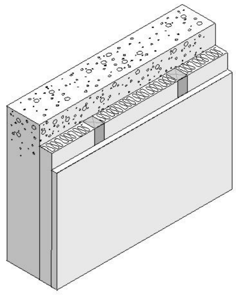
Values include air films on inner and outer surfaces.

Table IV.14 – Effective R-values for Interior or Exterior Insulation Layers Added to Structural Mass Walls

Metal Clips



Wood Framing



Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Notes: All furring thickness values given are actual dimensions. All values include .5" gypboard on the inner surface, interior surface resistances not included. The metal furring is 24" OC, 24 Gage, Z-type Metal Furring. The wood furring is 24" OC, Douglas-Fir Larch Wood Furring, density = 34.9 lb/ft³. Insulation assumed to fill the furring space

R-value of Insulation Installed in Furring Space

Thick-ness	Frame Type		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Any	None	1	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5
0.5"	Wood	2	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Na	na
	Metal	3	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Na	na
0.75"	Wood	4	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na	na	na	na	na	na	na	na	na	na	Na	na
	Metal	5	1.0	1.0	1.3	1.4	1.5	1.5	1.6	na	na	na	na	na	na	na	na	na	na	na	na	na	Na	na
1.0"	Wood	6	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na	na	na	na	na	na	na	na	na	na	Na	na
	Metal	7	1.0	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na	na	na	na	na	na	na	na	na	na	Na	na
1.5"	Wood	8	1.3	1.5	2.4	3.1	3.8	4.4	4.9	5.4	5.8	6.2	6.5	6.8	7.1	na	na	na	na	na	na	na	Na	na
	Metal	9	1.1	1.2	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	na	na	na	na	na	na	na	Na	na
2"	Wood	10	1.4	1.5	2.5	3.3	4.0	4.7	5.3	5.9	6.4	6.9	7.3	7.7	8.1	8.4	8.7	9.0	9.3	na	na	na	Na	na
	Metal	11	1.1	1.2	1.7	2.1	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	na	na	na	Na	na
2.5"	Wood	12	1.4	1.5	2.5	3.4	4.2	4.9	5.6	6.3	6.8	7.4	7.9	8.4	8.8	9.2	9.6	10.0	10.3	10.6	10.9	11.2	11.5	na
	Metal	13	1.2	1.3	1.8	2.3	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	na
3"	Wood	14	1.4	1.5	2.5	3.5	4.3	5.1	5.8	6.5	7.2	7.8	8.3	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.2	12.5	12.9
	Metal	15	1.2	1.3	1.9	2.4	2.8	3.1	3.3	3.5	3.7	3.8	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.7	4.8
3.5"	Wood	16	1.4	1.5	2.6	3.5	4.4	5.2	6.0	6.7	7.4	8.1	8.7	9.3	9.8	10.4	10.9	11.3	11.8	12.2	12.6	13.0	13.4	13.8
	Metal	17	1.2	1.3	2.0	2.5	2.9	3.2	3.5	3.8	4.0	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.3
4"	Wood	18	1.4	1.6	2.6	3.6	4.5	5.3	6.1	6.9	7.6	8.3	9.0	9.6	10.2	10.8	11.3	11.9	12.4	12.8	13.3	13.7	14.2	14.6
	Metal	19	1.2	1.3	2.0	2.6	3.0	3.4	3.7	4.0	4.2	4.5	4.6	4.8	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8
4.5"	Wood	20	1.4	1.6	2.6	3.6	4.5	5.4	6.2	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.7	12.3	12.8	13.3	13.8	14.3	14.8	15.2
	Metal	21	1.2	1.3	2.1	2.6	3.1	3.5	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.4	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3
5"	Wood	22	1.4	1.6	2.6	3.6	4.6	5.5	6.3	7.2	8	8.7	9.4	10.1	10.8	11.5	12.1	12.7	13.2	13.8	14.3	14.8	15.3	15.8
	Metal	23	1.2	1.4	2.1	2.7	3.2	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.8
5.5"	Wood	24	1.4	1.6	2.6	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.6	10.3	11.0	11.7	12.4	13.0	13.6	14.2	14.7	15.3	15.8	16.3
	Metal	25	1.3	1.4	2.1	2.8	3.3	3.8	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.2
EIFS		26	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0

~~**Source:** Berkeley Solar Group; Concrete Masonry Association of California and Nevada~~

~~**Notes:**~~

~~All furring thickness values given are actual dimensions~~

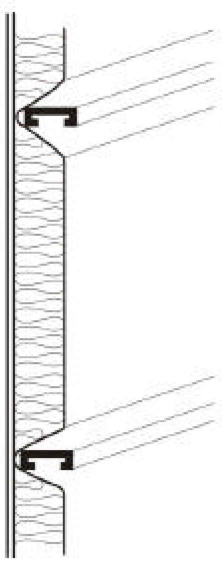
~~All values include .5" gypboard on the inner surface, interior surface resistances not included~~

~~The metal furring is 24" OC, 24 Gage, Z-type Metal Furring~~

~~The wood furring is 24" OC, Douglas-Fir Larch Wood Furring, density = 34.9 lb/cu.ft~~

~~Insulation assumed to fill the furring space~~

Table IV.15 – Standard U-factors for Metal Building~~[1]~~ Walls



Source: ASHRAE Standard 90.1-2001; NAIMA Compliance for Metal Buildings 1997.

Notes:

1 A wall must have metal framing no closer than 6 ft on center to use this table. Also, if the wall skin is connected to the girts more frequently than 12 in oc, 0.006 must be added to the U-factor in this table.

2 Single layer is perpendicular to the girts and positioned between the girts and the outer wall. Girts are horizontal purlins that span between the main vertical supports, to which the metal panel is attached.

3 First layer is perpendicular to the girts, between the girts and the outer wall. Second layer is inside the framing cavity.

			Rated R-Value of Continuous Insulation									
			None	R-4	R-6	R-8	R-10	R-12	R-15	R-20	R-25	R-30
Insulation System	**Rated R-Value of Insulation**		A	B	C	D	E	F	G	H	I	J
Single Layer of Batt Insulation[2]	None	1	1.18	0.206	0.146	0.113	0.092	0.078	0.063	0.048	0.039	0.032
	R-10	2	0.134	0.087	0.074	0.065	0.057	0.051	0.045	0.036	0.031	0.027
	R-11	3	0.123	0.082	0.071	0.062	0.055	0.050	0.043	0.036	0.030	0.026
	R-13	4	0.113	0.078	0.067	0.059	0.053	0.048	0.042	0.035	0.030	0.026
Double Layer of Batt Insulation[3]	R-13 + R-10	5	0.061	0.049	0.045	0.041	0.038	0.035	0.032	0.027	0.024	0.022
	R-13 + R-13	6	0.057	0.046	0.042	0.039	0.036	0.034	0.031	0.027	0.024	0.021

~~**Source:** ASHRAE Standard 90.1-2001; NAIMA Compliance for Metal Buildings 1997.~~

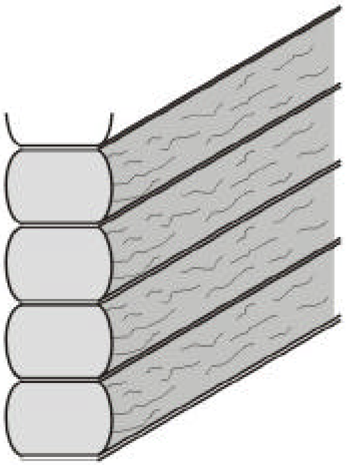
~~**Notes:**~~

~~1 A wall must have metal framing no closer than 6 ft on center to use this table. Also, if the wall skin is connected to the girts more frequently than 12 in oc, 0.006 must be added to the U-factor in this table.~~

~~2 Single layer is perpendicular to the girts and positioned between the girts and the outer wall. Girts are horizontal purlins that span between the main vertical supports, to which the metal panel is attached.~~

~~3 First layer is perpendicular to the girts, between the girts and the outer wall. Second layer is inside the framing cavity.~~

Table IV.16 – Thermal Properties of Log Home Walls



Source: ASHRAE Series method of calculation, ASHRAE Fundamentals Handbook.

Assumptions:

Values assume a log R-value of R-1.25/inch, an average wall thickness of 90% of the log diameter, an interior air film of R-0.62 and an exterior air film of R-0.17. Values do not account for presence of windows or doors. Construction assumes no additional siding or insulation.

Heat Capacity is based on a hardwood density of 26.6 lb/ft3 and a specific heat of 0.39 BTU/lb-F.

Log Diameter		U-factor	Heat CapacityBtu/ft^2*°F]
		A	
6"	**1**	0.133	4.04
8"	**2**	0.102	6.06
10"	**3**	0.083	6.73
12"	**4**	0.070	8.08
14"	**5**	0.060	9.42
16"	**6**	0.053	10.77

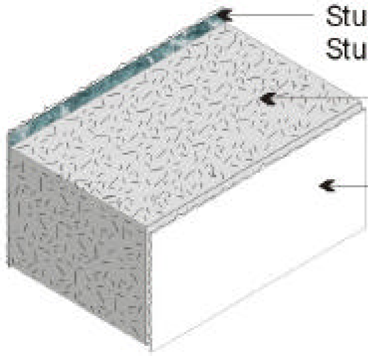
~~**Source:** ASHRAE Series method of calculation, ASHRAE Fundamentals Handbook.~~

~~**Assumptions:**~~

~~Values assume a log R-value of R-1.25/inch, an average wall thickness of 90% of the log diameter, an interior air film of R-0.62 and an exterior air film of R-0.17. Values do not account for presence of windows or doors. Construction assumes no additional siding or insulation.~~

~~Heat Capacity is based on a hardwood density of 26.6 lb/ft3 and a specific heat of 0.39 BTU/lb-F.~~

Table IV.17 – Thermal and Mass Properties of Straw Bale Walls



Notes:

Framing must not penetrate more than 25% of the way through the straw bale.

Straw bale must have a minimum cross section of 22 in. x 16 in., and shall have a thermal resistance of R-30, whether stacked so the walls are 23 in. wide or 16 in. wide. Due to the higher resistance to heat flow across the grain of the straws, a bale laid on edge with a nominal 16 in. horizontal thickness has the same R-value (R-30) as a bale laid flat.

		A
R-value	1	30
U-factor		0.033
Heat CapacityBtu/ft²*°F]		2.24

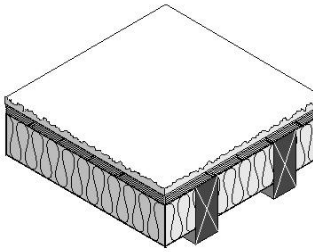
~~**Notes**:~~

~~Framing must not penetrate more than 25% of the way through the straw bale.~~

~~Straw bale must have a minimum cross section of 22 in. x 16 in., and shall have a thermal resistance of R-30, whether stacked so the walls are 23 in. wide or 16 in. wide. Due to the higher resistance to heat flow across the grain of the straws, a bale laid on edge with a nominal 16 in. horizontal thickness has the same R-value (R-30) as a bale laid flat.~~

IV.4 Floors and Slabs

Table IV.18 – Standard U-factors for Wood-Framed Floors with a Crawl Space



Source: ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook

Notes:

In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:

- Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
- Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

Assumptions:

These calculations assume an exterior air film of R-0.17, a vented crawlspace for an effective R-6, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92. The crawlspace is assumed to be equivalent to R-6 of additional insulation.

				Rated R-value of Continuous Insulation										
	Framing Type (Actual depth)	R-Value Cavity Insul.		R-0	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
Spacing				A	B	C	D	E	F	G	H	I	J	K
16 in. OC	2 x 6	None	1	0.099	0.090	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.049
	(3.5 in.)	R-11	2	0.050	0.047	0.045	0.043	0.042	0.040	0.038	0.037	0.036	0.034	0.033
		R-13	3	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.032	0.031
	2 x 8	R-19	4	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027
	(7.25 in.)	R-22	5	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025
	2 x 10	R-25	6	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.025	0.025	0.024	0.024
	(9.25 in.)	R-30	7	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022
	2 x 12 (11.25 in.)	R-38	8	0.024	0.023	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019
24 in. OC	2 x 6	None	9	0.092	0.084	0.077	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.048
	(3.5 in.)	R-11	10	0.049	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.035	0.034	0.033
		R-13	11	0.045	0.043	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031
	2 x 8	R-19	12	0.036	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027
	(7.25 in.)	R-22	13	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.026	0.025
	2 x 10	R-25	14	0.030	0.030	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023
	(9.25 in.)	R-30	15	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021
	2 x 12 (11.25 in.)	R-38	16	0.023	0.022	0.022	0.021	0.021	0.020	0.020	0.019	0.019	0.019	0.018

~~**Source:** ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook~~

~~**Notes:**~~

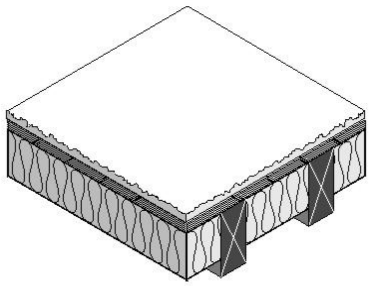
~~In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:~~

- ~~Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.~~
- ~~Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.~~

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, a vented crawlspace for an effective R-6, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92. The crawlspace is assumed to be equivalent to R-6 of additional insulation.~~

Table IV.19 – Standard U-factors for Wood Framed Floors without a Crawl Space



Source: ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook

Notes:

In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:

- Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
- Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

Assumptions:

These calculations assume an exterior air film of R-0.17, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92.

Spacing	Framing Type (Actual depth)	R-Value of Cavity Insul.		Rated R-value of Continuous Insulation										
				R-0	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
				A	B	C	D	E	F	G	H	I	J	K
16 in. OC	2 x 6	None	1	0.238	0.191	0.160	0.138	0.121	0.108	0.097	0.088	0.081	0.075	0.070
	(3.5 in.)	R-11	2	0.071	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041
		R-13	3	0.064	0.060	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.039
	2 x 8	R-19	4	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032
	(7.25 in.)	R-22	5	0.044	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030
	2 x 10	R-25	6	0.039	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027
	(9.25 in.)	R-30	7	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.025	0.025
	2 x 12 (11.25 in.)	R-38	8	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.022	0.022	0.021
24 in. OC	2 x 6	None	9	0.199	0.165	0.142	0.124	0.110	0.099	0.090	0.083	0.076	0.071	0.066
	(3.5 in.)	R-11	10	0.070	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041
		R-13	11	0.062	0.059	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.040	0.038
	2 x 8	R-19	12	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032
	(7.25 in.)	R-22	13	0.042	0.040	0.039	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029
	2 x 10	R-25	14	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027
	(9.25 in.)	R-30	15	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.025	0.025	0.024
	2 x 12 (11.25 in.)	R-38	16	0.027	0.026	0.025	0.025	0.024	0.023	0.023	0.022	0.022	0.021	0.021

~~**Source:** ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook~~

~~**Notes:**~~

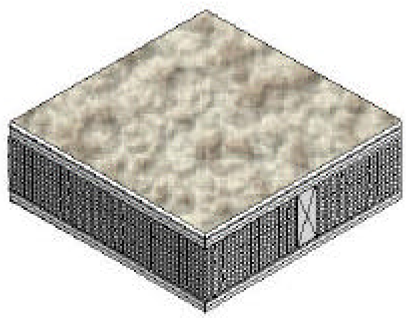
~~In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:~~

- ~~Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.~~
- ~~Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.~~

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92.~~

Table IV.20 – Standard U-factors for Wood Foam Panel (SIP) Floors



Source: ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook

Assumptions:

These calculations assume an exterior air film of R-0.17, a vented crawlspace with an effective R-6, 7/16" of OSB of R-0.69, the insulation / framing layer, 7/16" of OSB, carpet and pad of R-2.08(CP01) and an interior air film (heat flow down) of R-0.92. Calculations assume a 2x framing spline every 4' o.c. Framing section assumes an exterior air film of R-0.17, a vented crawlspace of R-6, 7/16" of OSB at R-0.69, 2x framing, 7/16" of OSB, carpet and pad of R-2.08(CP01) and an interior air flim of R-0.92.

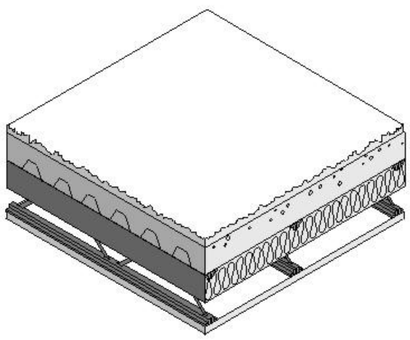
			U-factor	
			No CrawlSpace	With CrawlSpace
Insulation R-value	**Panel Thickness**		**A**	**B**
R-14	4 ½"	**1**	0.058	0.042
R-22	6 ½"	**2**	0.038	0.033
R-28	8 ¼"	**3**	0.030	0.028
R-36	10 ¼"	**4**	0.025	0.021

~~**Source:** ASHRAE Parallel Heat Flow Calculation, ASHRAE Fundamentals Handbook~~

~~**Assumptions**:~~

~~These calculations assume an exterior air film of R-0.17, a vented crawlspace with an effective R-6, 7/16" of OSB of R-0.69, the insulation / framing layer, 7/16" of OSB, carpet and pad of R-2.08(CP01) and an interior air film (heat flow down) of R-0.92. Calculations assume a 2x framing spline every 4' o.c. Framing section assumes an exterior air film of R-0.17, a vented crawlspace of R-6, 7/16" of OSB at R-0.69, 2x framing, 7/16" of OSB, carpet and pad of R-2.08(CP01) and an interior air flim of R-0.92.~~

Table IV.21 – Standard U-factors for Metal-Framed Floors with a Crawl Space



Source: ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook

Notes:

In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:

- Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
- Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

Assumptions:

These calculations assume an exterior air film of R-0.17, a vented crawlspace for an effective R-6, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92. The effect of the crawlspace is approximated by an additional R-6 of insulation.

Spacing	Framing Type (Actual depth)	Cavity Insulation R-Value:		Rated R-value of Continuous Insulation R-0	R-2	R-4	R-6	R-8	R-10	R-12	R-15	R-20	R-25	R-30
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
16 in. OC	2 x 6	None (0.0)	**1**	0.095	0.080	0.069	0.060	0.054	0.049	0.044	0.039	0.033	0.028	0.025
		R-11	**2**	0.065	0.057	0.051	0.047	0.043	0.039	0.036	0.033	0.028	0.025	0.022
		R-13	**3**	0.062	0.055	0.050	0.045	0.041	0.038	0.035	0.032	0.028	0.024	0.022
	2 x 8	R-19	**4**	0.062	0.055	0.050	0.045	0.042	0.038	0.036	0.032	0.028	0.024	0.022
		R-22	**5**	0.065	0.057	0.051	0.047	0.043	0.039	0.036	0.033	0.028	0.025	0.022
	2 x 10	R-30	**6**	0.055	0.050	0.045	0.042	0.038	0.036	0.033	0.030	0.026	0.023	0.021
	2 x 12	R-38	**7**	0.044	0.040	0.037	0.035	0.032	0.030	0.029	0.026	0.023	0.021	0.019
24 in. OC	2 x 6	None (0.0)	**8**	0.095	0.079	0.069	0.060	0.054	0.049	0.044	0.039	0.033	0.028	0.025
		R-11	**9**	0.064	0.057	0.051	0.046	0.042	0.039	0.036	0.033	0.028	0.025	0.022
		R-13	**10**	0.061	0.054	0.049	0.045	0.041	0.038	0.035	0.032	0.027	0.024	0.022
	2 x 8	R-19	**11**	0.060	0.054	0.049	0.044	0.041	0.038	0.035	0.032	0.027	0.024	0.021
		R-22	**12**	0.059	0.053	0.048	0.043	0.040	0.037	0.034	0.031	0.027	0.024	0.021
	2 x 10	R-30	**13**	0.054	0.048	0.044	0.041	0.038	0.035	0.033	0.030	0.026	0.023	0.021
	2 x 12	R-38	**14**	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.026	0.023	0.021	0.019

~~**Source:** ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook~~

~~**Notes:**~~

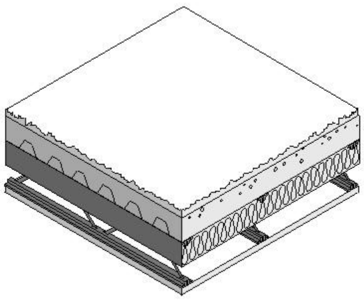
~~In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:~~

- ~~Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.~~
- ~~Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.~~

~~**Assumptions:**~~

~~These calculations assume an exterior air film of R-0.17, a vented crawlspace for an effective R-6, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92. The effect of the crawlspace is approximated by an additional R-6 of insulation.~~

Table IV.22 – Standard U-factors for Metal-Framed Floors without a Crawl Space



Source: ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook

Notes:

In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:

- Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
- Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

Assumptions:

These calculations assume an exterior air film of R-0.17, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92.

Spacing	Framing Type (Actual depth)	Cavity Insulation R-Value		Rated R-value of Continuous Insulation										
				R-0	**R-2**	**R-4**	**R-6**	**R-8**	**R-10**	**R-12**	**R-15**	**R-20**	**R-25**	**R-30**
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
16 in. OC	2 x 6	None	**1**	0.253	0.168	0.126	0.101	0.084	0.072	0.063	0.053	0.042	0.035	0.029
		R-11	**2**	0.106	0.087	0.074	0.065	0.057	0.051	0.047	0.041	0.034	0.029	0.025
		R-13	**3**	0.098	0.082	0.070	0.062	0.055	0.050	0.045	0.040	0.033	0.028	0.025
	2 x 8	R-19	**4**	0.100	0.083	0.071	0.062	0.055	0.050	0.045	0.040	0.033	0.029	0.025
		R-22	**5**	0.106	0.087	0.074	0.065	0.057	0.051	0.047	0.041	0.034	0.029	0.025
	2 x 10	R-30	**6**	0.083	0.071	0.062	0.055	0.050	0.045	0.042	0.037	0.031	0.027	0.024
	2 x 12	R-38	**7**	0.059	0.053	0.048	0.044	0.040	0.037	0.035	0.031	0.027	0.024	0.021
24 in. OC	2 x 6	None	**8**	0.253	0.168	0.126	0.101	0.084	0.072	0.063	0.053	0.042	0.035	0.029
		R-11	**9**	0.103	0.086	0.073	0.064	0.057	0.051	0.046	0.041	0.034	0.029	0.025
		R-13	**10**	0.096	0.080	0.069	0.061	0.054	0.049	0.045	0.039	0.033	0.028	0.025
	2 x 8	R-19	**11**	0.094	0.079	0.068	0.060	0.054	0.049	0.044	0.039	0.033	0.028	0.025
		R-22	**12**	0.091	0.077	0.067	0.059	0.053	0.048	0.043	0.038	0.032	0.028	0.024
	2 x 10	R-30	**13**	0.079	0.068	0.060	0.054	0.048	0.044	0.041	0.036	0.031	0.027	0.023
	2 x 12	R-38	**14**	0.057	0.051	0.046	0.042	0.039	0.036	0.034	0.031	0.027	0.023	0.021

~~**Source:** ASHRAE Zone Method Calculation, 2001 ASHRAE Fundamentals Handbook~~

~~**Notes:**~~

~~In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:~~

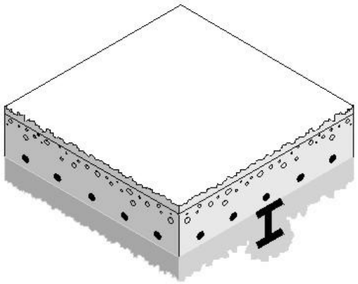
- ~~Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.~~
- ~~Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.~~

~~**Assumptions:**~~

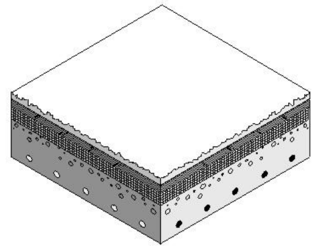
~~These calculations assume an exterior air film of R-0.17, a continuous insulation layer (if any), the insulation / framing layer, 5/8" of plywood of R-0.78(PW04), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92.~~

Table IV.23 – Standard U-factors for Concrete Raised Floors

Continuous Insulation Underneath



Continuous Insulation Abovedeck



R-value of Insulation		Rated R-value of Continuous Insulation	
		Continuous Insulation Underneath	Continuous Insulation Above Deck[1]
		A	B
R-0	1	0.315	0.253
R-2	2	0.193	0.168
R-4	3	0.139	0.126
R-6	4	0.109	0.101
R-8	5	0.090	0.084
R-10	6	0.076	0.072
R-12	7	0.066	0.063
R-15	8	0.055	0.053
R-20	9	0.043	0.042
R-25	10	0.035	0.035
R-30	11	0.030	0.029

Notes:

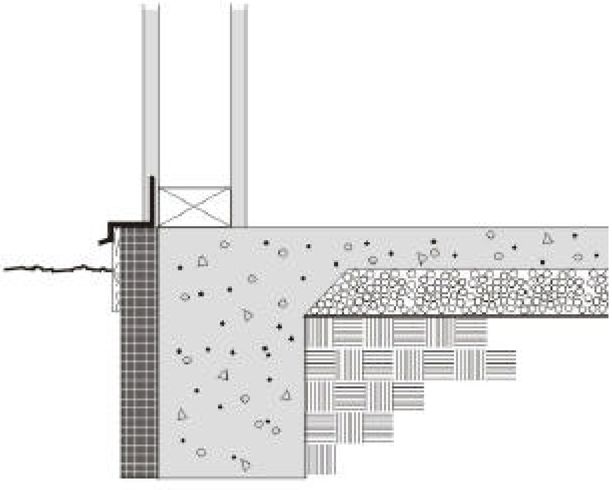
[1] Above deck case includes a 5/8" layer of plywood between the insulation and the carpet and pad.

This table may be used only if the HC of the proposed design floor is greater than or equal to 7.0 Btu/ft²-ºF.

Assumptions:

These calculations assume an exterior air film of R-0.17, a continuous insulation layer (if any), 4 in. of the lightweight concrete (CC14) over metal deck R-0, a continuous insulation layer (if any), 5/8" of plywood of R-0.78(PW04) (if continuous insulation above deck), carpet and pad of R-2.08(CP01), and an interior air film (heat flow down) of R-0.92.

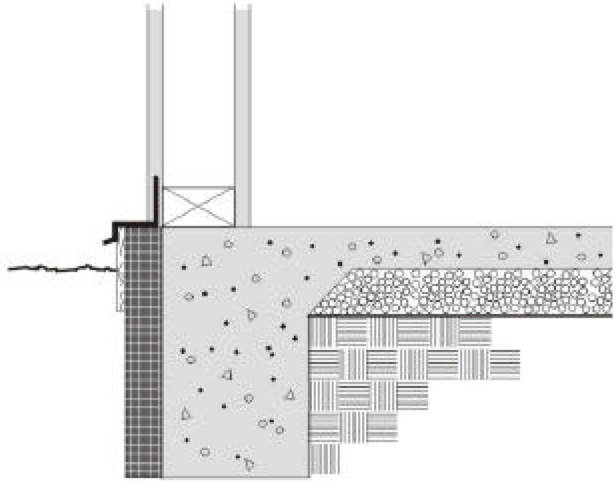
Table IV.24 – F-Factors for Unheated Slab-on-Grade Floors



Note: These values are used for slab edge conditions with and without carpet.

		Rated R-Value of Insulation												
Insulation Description		R-0	R-5	R-7.5	R-10	R-15	R-20	R-25	R-30	R-35	R-40	R-45	R-50	R-55
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
None	**1**	0.73												
12 in. horizontal	**2**		0.72	0.71	0.71	0.71								
24 in. horizontal	**3**		0.70	0.70	0.70	0.69								
36 in. horizontal	**4**		0.68	0.67	0.66	0.66								
48 in. horizontal	**5**		0.67	0.65	0.64	0.63								
12 in. vertical	**6**		0.61	0.60	0.58	0.57	0.567	0.565	0.564					
24 in. vertical	**7**		0.58	0.56	0.54	0.52	0.510	0.505	0.502					
36 in. vertical	**8**		0.56	0.53	0.51	0.48	0.472	0.464	0.460					
48 in. vertical	**9**		0.54	0.51	0.48	0.45	0.434	0.424	0.419					
Fully insulated slab	**10**		0.46	0.41	0.36	0.30	0.261	0.233	0.213	0.198	0.186	0.176	0.168	0.161
~~**HEATED SLABS**~~														
~~Note: These values are used for slab edge conditions and without carpet.~~														
~~Note: These values are used for slab edge conditions with and without carpet.~~														

Table IV.25 – F-Factors for Heated Slab-on-Grade Floors



Note: These values are used for slab edge conditions with and without carpet.

		Rated R-Value of Insulation												
		R-0	R-5	R-7.5	R-10	R-15	R-20	R-25	R-30	R-35	R-40	R-45	R-50	R-55
		A	B	C	D	E	F	G	H	I	J	K	L	M
None	~~1~~1	1.35												
12 in. horizontal	~~1~~2		1.31	1.31	1.30	1.30								
24 in. horizontal	~~1~~3		1.28	1.27	1.26	1.25								
36 in. horizontal	~~1~~4		1.24	1.21	1.20	1.18								
48 in. horizontal	~~1~~5		1.20	1.17	1.13	1.11								
12 in. vertical	~~1~~6		1.06	1.02	1.00	0.98	0.968	0.964	0.961					
24 in. vertical	~~1~~7		0.99	0.95	0.90	0.86	0.843	0.832	0.827					
36 in. vertical	~~1~~8		0.95	0.89	0.84	0.79	0.762	0.747	0.740					
48 in. vertical	~~1~~9		0.91	0.85	0.78	0.72	0.688	0.671	0.659					
Fully insulated slab	~~2~~10		0.74	0.64	0.55	0.44	0.373	0.326	0.296	0.273	0.255	0.239	0.227	0.217

~~Note: These values are used for slab edge conditions with and without carpet.~~

IV.5 Miscellaneous Construction

Table IV.26 – Opaque Doors

Description		U-factor (Btu/ºF-ft²)
		A
Uninsulated single-layer metal *swinging doors* or *non-swinging doors*, including single-layer uninsulated access hatches and uninsulated smoke vents:	**1**	1.45
Uninsulated double-layer metal *swinging doors* or *non-swinging doors*, including double-layer uninsulated access hatches and uninsulated smoke vents:	**2**	0.70
Insulated metal *swinging doors*, including fire-rated *doors*, insulated access hatches, and insulated smoke vents:	**3**	0.50
Wood *doors*, minimum nominal thickness of 1-3/4 in. (44 mm), including panel *doors* with minimum panel thickness of 1-1/8 in. (28 mm), and solid core flush *doors*, and hollow core flush *doors*:	**4**	0.50
Any other wood *door*:	**5**	0.60
Source: ASHRAE 90.1-2001, Section A7.		

IV.6 Modeling Constructions in the Nonresidential ACM

DOE-2 is the reference method for nonresidential ACMs. With DOE-2, construction assemblies are defined by specifying layers. Notes to each of the tables in this appendix describe the layers that are used to determine the U-factors. The codes in parenthesis are a reference to the DOE-2 material codes used in the calculations. These codes along with other materials referenced in the notes are shown ~~in Table 27~~ below. The thermal properties of concrete and masonry products are not documented below, however, because the standard DOE-2 material codes shall be used.

~~Table 27~~ DOE-2 Material Codes ~~for Materials Used~~

Code	Description	R-value	Thickness	Conductivity	Density	Specific Heat
AR02	Asphalt Shingle & Siding	0.44			70.0	0.35
BP01	Building Paper, Permeable Felt	0.06				
PW03	Plywood 1/2 in.	0.63	0.0417	0.0667	34.0	0.29
GP01	Gypsum Board 1/2 in.	0.45	0.0417	0.0926	50.0	0.20
BR01	Built-up Roofing 3/8 in.	0.33	0.0313	0.0939	70.0	0.35
PW05	Plywood 3/4 in.	0.94	0.0625	0.0667	34.0	0.29
PW04	Plywood 5/8 in.	0.78	0.0521	0.0667	34.0	0.29
CP01	Carpet with Fibrous Pad	2.08				0.34
PB01	Particle Board Low Density 3/4 in.	1.39	0.0625	0.0450	75.0	0.31
SC01	Stucco 1 in.	0.20	0.0833	0.4167	116.0	0.20
WD05	Wood, Soft 4 in.	5.00	0.3333	0.0667	32.0	0.33
WD11	Wood, Hard 3/4 in.	0.68	0.0625	0.0916	45.0	0.30
CC03	Heavy Wt. Dried Aggregate 4 in.	0.44	0.3333	0.7576	140.0	0.20
CC14	Heavy Wt. Undried Aggregate 4 in.	0.32	0.3333	1.0417	140.0	0.20
AC02	1/2 in. Acoustic Tile	1.26	0.0417	0.0330	18.0	0.32
AL33	Air Layer 4 in. or more, Horizontal Roof	0.92	1.0000	0.4167	120.0	0.20
CP01	Carpet with Fibrous Pad	2.08				0.34
Custom	Earth (Soil)	3.00	1.5000	0.5000	85.0	0.20
Custom	Logs 6 in.	7.50	0.5000	0.0667	32.0	0.33
Custom	Logs 8 in.	10.00	0.6667	0.0667	32.0	0.33
Custom	Logs 10 in.	12.49	0.8333	0.0667	32.0	0.33
Custom	Logs 12 in.	14.99	1.0000	0.0667	32.0	0.33
Custom	Logs 14 in.	17.49	1.1667	0.0667	32.0	0.33
Custom	Logs 16 in.	19.99	1.3333	0.0667	32.0	0.33
Custom	Earth 12 in.	2.00	1.0000	0.5000	85.0	0.20
Custom	Vented crawspace	6.00	n.a.	n.a.	n.a.	n.a.
Custom	7/8" layer of stucco of R-0.18	0.18	0.0729	0.4167	116.0	0.20
Custom	Straw bale	30.00				
Custom	Acoustic tile + Metal	0.50	0.0417	0.0330	18.0	0.32
Custom	OSB 7/16 in.	0.55	0.0365	0.0667	34.0	0.29

The R-value of insulation/framing layer shall be determined to achieve the U-factor shown in the tables in this appendix. The insulation/framing layer shall be modeled with an R-value, as opposed to entering conductivity, specific heat, density and thickness.

Metal building walls and metal building roofs shall be modeled in the DOE-2 reference method as quick surfaces, e.g., thermal mass is not modeled. In these cases, no layers are specified, just the U-factor.

Note. For nonresidential buildings, slab edge conditions shall be modeled as 12 in. of concrete and 12 in. of earth, and a layer of insulation exterior to the earth that achieves the F-factors shown above.

V. APPENDIX 1-A
STANDARDS AND DOCUMENTS REFERENCED IN THE ENERGY EFFICIENCY REGULATIONS

~~STATE OF CALIFORNIA~~

~~Appliance Efficiency Regulations~~

~~Quality Standards for Insulating Material~~

~~Nonresidential Manual~~

~~Residential Manual~~

~~Various Directories for Certified Appliances~~

~~Available from:~~ ~~California Energy Commission~~
~~Publications Office~~
~~1516 Ninth Street, MS-13~~
~~Sacramento, California 95814-5512~~
~~(916) 654-5200~~

~~CONSUMER GUIDE TO CERTIFIED INSULATING MATERIALS~~

~~Available from:~~ ~~Consumer Affairs~~
~~Insulation Quality Standards~~
~~(916) 574-2060~~

~~INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS~~

~~Uniform Building Code, 1997 Edition~~

~~California Mechanical Code, 1998 Edition~~

~~Available from:~~ ~~International Conference of Building Officials~~
~~5360 South Workman Mill Road~~
~~Whittier, California 90601~~
~~(562) 699-0541~~

AIR-CONDITIONING AND REFRIGERATION INSTITUTE

ARI 210/240-94	~~Standard for~~ Unitary Air Conditioning and Air-Source Heat Pump Equipment (1994)
ARI 310/380-93	~~Standard for~~ Packaged Terminal Air-Conditioners and Heat Pumps (1993)
ARI 320-98	~~Standard for~~ Water-Source Heat Pumps
ARI 325-98	~~Standard for~~ Ground Water-Source Heat Pumps (1998)
~~ARI 330-98~~	~~Ground Source Closed-Loop Heat Pumps~~
ARI 340/360-~~93~~01	~~Standard for~~ Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment (2001)
ARI 365-94 (1994)	~~Standard for~~ Commercial and Industrial Unitary Air-Conditioning Condensing Units
ARI 460-~~20~~00	~~Standard for~~ Remote Mechanical-Draft Air-Cooled Refrigerant Condensers (2000)
ARI 550/590-98~~-92~~	Standard for ~~Centrifugal or Rotary Screw~~ Water-Chilling Packages Using the Vapor Compression Cycle (1998)
ARI 560-92	~~Standard for~~ Absorption Water Chilling and Water Heating Packages (2000)

~~ARI 590-1992 Standard for Positive Displacement Compressor Reciprocating Water-Chilling Packages~~

Available from: Air-Conditioning and Refrigeration Institute
4301 North Fairfax Drive, Suite 425
Arlington, Virginia 22203
(703) 524-8800

AIR CONDITIONING CONTRACTORS OF AMERICA

Manual J – Residential Load Calculation, Eighth Edition (2003)

Available from:
Air Conditioning Contractors of America, Inc.
2800 Shirlington Road, Suite 300,
Arlington, VA 22206

(703) 575-4477
www.acca.org
~~PHONE (703) 575-4477,~~
~~FAX (703) 575-9101~~

~~1712 New Hampshire Avenue, NW~~

~~Washington, DC 20009~~

~~www.acca.org/catalog/product.asp~~

~~(202) 483-9370~~

~~FAX (202) 232-8545~~

AMERICAN NATIONAL STANDARDS INSTITUTE

ANSI Z21.10.3-2001 Gas Water Heaters, Volume 1, Storage Water Heaters with Input Ratings above 75,000 Btu/h (2001)

ANSI Z21.13-2000 Gas-Fired Low Pressure Steam and Hot Water Boilers (2000)

ANSI Z21.40.4-1996 Performance Testing and Rating of Gas-Fired, Air-Conditioning and Heat Pump Appliances (1996)

ANSI Z21.47-2001 Gas-Fired Central Furnaces (2001)

ANSI Z83.8-2002 Gas Unit Heaters and Gas-Fired Duct Furnaces (2002)

Available from: American National Standards Institute
25 West 43rd Street, 4th floor
New York, NY 10036
(212) 642-4900

AMERICAN SOCIETY OF HEATING, REFRIGERATI~~O~~NG, AND AIR-CONDITIONING ENGINEERS (NATIONAL PUBLICATIONS)[1]

~~Handbook and Product Directory~~

~~Equipment Volume, 2000 Edition~~

~~HVAC Applications Volume, Chapter 48, 1999 Edition~~

~~Fundamentals Volume, 1993 and 1997 Edition~~

~~STANDARDS~~

1 COMMENTARY: The justification for this change appears in Eley Associates, "Maximum Allowable Cooling Capacity," *Measure Analysis and Life-Cycle Cost: 2005 California Building Energy Efficiency Standards, Part III*, July 3, 2002, p. 6-16. Presented at the July 18, 2002 workshop.

~~ANSI/~~ASHRAE 55-1992 Thermal Environment Conditions for Human Occupancy (1992)

~~ASHRAE 62-89 Standards for Natural and Mechanical Ventilation and Ventilation for Acceptable Indoor Air Quality~~

ASHRAE Handbook,

Applications Volume, Heating, Ventilating and Air-Conditioning Applications (1999)

Equipment Volume, Heating, Ventilating and Air-Conditioning Systems and Equipment (2000)

Fundamentals Volume, Fundamentals (2001)

Available from: ASHRAE
1791 Tullie Circle N.E.
Atlanta, Georgia 30329
(404) 636-8400 or (800) 527-4723

AMERICAN SOCIETY OF HEATING, REFRIGERATI~~O~~NG, AND AIR-CONDITIONING ENGINEERS (REGIONAL PUBLICATION~~S~~)[2]

~~Recommended Outdoor Design Temperatures for Northern California, 1977~~

~~Available from: ASHRAE~~
~~Golden Gate Chapter~~
~~370 Brannan Street~~
~~San Francisco, California 94102~~
~~(415) 495-4552~~

~~Climatic Data For Region X, Arizona, California, Hawaii, and Nevada, Publication SPCDX, 1982~~

~~Available from: ASHRAE - Climatic Data~~
~~Southern California Chapter~~
~~Post Office Box 6306~~
~~Alhambra, California 91802~~

ASHRAE Climatic Data for Region X Arizona, California, Hawaii, Nevada, Publication SPCDX, 1982, ISBN #20002196 and Supplement, 1994, ISBN #20002596
Available from: Order Desk
Building News
10801 National Boulevard
Los Angeles, CA 90064
(800) 873-6397 or (310) 474-7771
http://www.bnibooks.com/

~~**AMERICAN NATIONAL STANDARDS – Z21 SERIES**~~

~~ANSI Z21.10.3-1998 Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h , Circulating and Instantaneous Water Heaters~~

~~ANSI Z21.13-91 Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers~~

~~ANSI Z21.47-1998 Standard for Gas-Fired Central Furnaces~~

~~ANSI Z21.56-1998 Standards for Gas-Fired Swimming Pool Heaters~~

~~ANSI Z83.8-1990 Standards for Gas Unit Heaters~~

~~ANSI Z83.9-1990 Standards for Gas-Fired Duct Furnaces~~

~~Available from: American Gas Association Laboratories~~
~~8501 East Pleasant Valley Road~~

[2] COMMENTARY: Ibid.

	~~Cleveland, Ohio 44131~~ ~~(216) 524-4990~~

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM C55-01	Standard Specification for Concrete Brick (2001)
ASTM C~~-~~177-~~85~~97	Standard Test Method for Steady~~-~~-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus (1997)
ASTM C272-01	Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions (2001)
ASTM C~~-~~335-95	Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation (1995)
ASTM C~~-~~518-~~91~~02	Standard Test Method for Steady-State ~~Heat Flux Measurements and~~ Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus (2002)
ASTM C731-00~~93a~~	Standard Test Method for Extrudability, After Package Aging, of Latex Sealants (2000)
ASTM C 732-01~~95~~	Standard Test Method for Aging Effects of Artificial Weathering on Latex Sealants (2001)
~~ASTM C271-94~~	~~Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions~~
ASTM C 1167-96	Standard Specification for Clay Roof Tiles
ASTM C1371-98	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers (1998)~~.~~
~~ASTM E408-71(1996)e1~~	~~Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques~~
ASTM D1003-00	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics~~,~~ (2000) ~~notwithstanding its scope or other test method approved by the California Energy Commission.~~
~~ASTM D 2202-93a~~	~~Standard Test Method for Slump of Sealants~~
~~ASTM D6083-97a~~	~~Standard Specification for Liquid Applied Acrylic Coating Used in Roofing~~
ASTM D4798-01	Standard Test Method Accelerated Weathering Test Conditions and Procedures for Bituminours Materials (Xenon-Arc Method) (2001)
ASTM E~~-~~96-~~95~~00	Standard Test Methods for Water Vapor Transmission of Materials
~~ASTM E 283-91~~	~~Standard Method of Test for Air Leakage Through Exterior Windows, Curtain Walls, and Doors~~
ASTM E 283-91 (1999)	Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E408-71-~~71(1996)e1~~(2002)	Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques (2002)
~~ASTM E903-96~~	~~Standard Test Method for Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres~~
~~ASTM E1918-97~~	~~Standard Test Method for Measuring Solar Reflectance of Horizontal and Low Sloped Surfaces in the Field~~
Available from:	American Society for Testing and Materials 100 Barr Harbor Drive

West Conshohocken, Pennsylvania 19428-2959
(610) 832-9500

~~AMERICAN NATIONAL STANDARDS/UNDERWRITERS LABORATORIES~~

~~ANSI/UL 726-90 Oil-Fired Boiler Assemblies~~

~~ANSI/UL 727-86 Oil-Fired Control Furnaces~~

~~UL 181 Standard for Safety for Factory-made Air Ducts and Connectors~~

~~UL 181A Standard for Safety for Closure Systems for Use with Rigid Air Ducts and Air Connectors~~

~~UL 181B Standard for Safety for Closure Systems for Use with Flexible Air Ducts and Air Connectors~~

~~UL 731-95 Oil-Fired Unit Heaters~~

~~UL 795-94 Commercial-Industrial Gas-Heating Equipment~~

~~Available from: Underwriters Laboratories~~
~~333 Pfingsten Road~~
~~Northbrook, Illinois 60062-2096~~
~~(847) 272-8800~~

~~AMERICAN SOCIETY OF MECHANICAL ENGINEERS~~

~~ANSI/ASME PTC 4.1-64 Steam Generating Units~~

~~Available from: ANSI~~
~~1430 Broadway~~
~~New York, NY 10017~~
~~(212) 868-1220~~

~~ASSOCIATION OF HOME APPLIANCE MANUFACTURERS~~

~~ANSI/AHAM RAC-1-87 Room Air Conditioners~~

~~Available from: AHAM~~
~~20 North Wacker Drive~~
~~Chicago, IL 60606~~

CALIFORNIA BUILDING STANDARDS COMMISSION

2001 California Electrical Code

Available from: California Building Standards Commission
2525 Natomas Park Drive, Suite 130
Sacramento, CA 95833-2936
(916) 263-0916
www.bsc.ca.gov

CALIFORNIA ENERGY COMMISSION

Appliance Efficiency Standards

Nonresidential Alternative Calculation Method (ACM) Manual

Nonresidential Manual

Residential Alternative Calculation Method (ACM) Manual

Residential Manual

Available from: California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

(916) 654-5106 or
(800) 772-3300 (in California)
http://www.energy.ca.gov/title24

CALIFORNIA DEPARTMENT OF CONSUMER AFFAIRS

Standards for Insulating Material

Available from: California Department of Consumer Affairs
Bureau of Home Furnishings and Thermal Insulation
3485 Orange Grove Ave
North Highlands, CA 95660
(916) 574-2041

CODE OF FEDERAL REGULATIONS

~~10 CFR, Part 430, Appendix N~~

21 Code of Federal Regulations~~CFR~~, Section 1002.2 (1996)

47 Code of Federal Regulations~~CFR~~, Parts 2 and 15 (1996)

Available from: Department of Energy
Washington, DC 20585

COOLING TOWER INSTITUTE

CTI ATC-105 ~~(97)~~-00 Acceptance Test Code for Water Cooling Towers (2000)

CTI STD-201 ~~(1996)~~-02 Certification Standard for Commercial Water Cooling Towers (2002)

Available from: Cooling Tower Institute
530 Wells Fargo, Suite 218
Post Office Box 73383
Houston, Texas 77273
(281) 583-4087

COOL ROOF RATING COUNCIL

CRRC-1 Product Rating Program Manual (2002)

Available from: Cool Roof Rating Council
1738 Excelsior Avenue
Oakland, CA 94602
(866) 465-2523

~~FAX (510) 482-4421~~
www.coolroofs.org

HYDRONICS INSTITUTE

HI Heating Boiler Standard 86, 6th Edition, ~~June~~ (1989)

Available from: Hydronics Institute
35 Russo Place, P.O. Box 218
Berkeley Heights, New Jersey 07922
(908) 464-8200

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA

~~Office Lighting American National Standard Practice ANSI/IES RP-1~~

~~1993 IES Handbook, Applications Volume (1987 edition)~~

The IESNA Lighting Handbook, Ninth Edition (2000)

Available from: IESNA
120 Wall Street, 17th Floor
New York, New York 10005-4001
(212) 248-5000
~~FAX (212) 248-5017~~
Email: iesna@iesna.org

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

2001 California Building Code

2001 California Mechanical Code~~,~~

Available from: International Conference of Building Officials
5360 South Workman Mill Road
Whittier, California 90601
(562) 699-0541

~~ISO~~INTERNATIONAL ORGANIZATION FOR STANDARDIZATION~~ISO~~

ISO-13256-1 Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps (1998)

Available from: ISO
1, rue de Varembe
Case postale 56
CH-1211
Geneve 20, Switzerland

~~ASSOCIATED AIR BALANCE COUNCIL~~

~~AABC National Standards, 5th Edition, 1989~~

~~Available from: Associated Air Balance Council~~
~~1518 K Street, NW, Suite 503~~
~~Washington, DC 20005~~
~~(202) 737-0202~~

~~NEBB Procedural Standards (1983)~~

NATIONAL FENESTRATION RATING COUNCIL[3]

NFRC 100 Procedure for Determining Fenestration Product U-factors (1997, 2002)

NFRC 200 Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence (1995, 2002)

NFRC 400 Procedure for Determining Fenestration Product Air Leakage (1995, 2002)

Available from: National Fenestration Rating Council
8484 Georgia Avenue, Suite 320
Silver Spring, Maryland 20910
(301) 589-1776
~~FAX (301) 589-3884~~
Email: info@nfrc.org

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION

~~HVAC Duct Construction Standards–Metal and Flexible, 1995, 2nd Edition~~

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[3] COMMENTARY: The justification for this change appears in Pacific Gas and Electric Company, *Window Efficiency Requirements Upon Window Replacement*, *Code Change Proposal, 2005 Title 24 Building Energy Efficiency Standards Update*, March 15, 2002. Presented at the April 23, 2002 workshop.

~~Installation Standards for~~ Residential Comfort System Installation Standards Manual (1998)~~Heating and Air Conditioning Systems~~

Available from: Sheet Metal And Air Conditioning Contractors National Association (SMACNA)
4201 Lafayette Center Drive~~1020 12th Street, Suite 101~~
Chantilly, VA 20151-1209~~Sacramento, California 95814~~
(703) 803-2980~~(916) 442-3807~~
~~FAX (916) 442-6541~~www.smacna.org

~~NATIONAL FENESTRATION RATING COUNCIL~~[4]

~~NFRC 100~~ ~~Procedure for Determining Fenestration Product U-factors~~

~~NFRC 200~~ ~~Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence~~

~~NFRC 400~~ ~~Procedure for Determining Fenestration Product Air Leakage~~

~~Available from:~~ ~~National Fenestration Rating Council~~
~~8484 Georgia Avenue, Suite 320~~
~~Silver Spring, Maryland 20910~~
~~(301) 589-1776~~
~~FAX (301) 589-3884~~
~~Email: info@nfrc.org~~

UNDERWRITERS LABORATORIES

UL 181 Standard for Safety for Factory-made Air Ducts and Connectors (1996)

UL 181A Standard for Safety for Closure Systems for Use with Rigid Air Ducts and Air Connectors (1994)

UL 181B Standard for Safety for Closure Systems for Use with Flexible Air Ducts and Air Connectors (1995)

UL 723 Standard for Test for Surface Burning Characteristics of Building Materials (1996)

UL 727 Standard for Oil-Fired Central Furnaces (1994)

UL 731 Standard for Oil-Fired Unit Heaters (1995)

UL 1598 Standard for Luminaires (2000)

Available from: Underwriters Laboratories
333 Pfingsten Road
Northbrook, Illinois 60062-2096
(847) 272-8800

~~STATE OF CALIFORNIA~~

~~Appliance Efficiency Regulations~~

~~Nonresidential Manual~~

~~Quality Standards for Insulating Material~~

~~Residential Manual~~

~~Various Directories for Certified Appliances~~

~~Available form: California Energy Commission~~

~~Publications Office~~

4 COMMENTARY: The justification for this change appears in Pacific Gas and Electric Company, *Window Efficiency Requirements Upon Window Replacement*, *Code Change Proposal, 2005 Title 24 Building Energy Efficiency Standards Update*, March 15, 2002. Presented at the April 23, 2002 workshop.

~~1516 Ninth Street, MS-13~~

~~Sacramento, California 95814-5512~~

~~(916) 654-5200~~

RESIDENTIAL CHANGES

Residential Kitchen Lighting Alterations

EXCEPTION 1 to Section 152 (b): The EXCEPTION to Section 150 (k) 2 applies only for alterations to kitchen lighting where all permanently installed kitchen luminaires are replaced.

Residential Field Verification CF-1R Notification

~~2.1.3~~V.1.1 General Information

This listing in the Certificate of Compliance follows the first page heading and provides basic information about the building. A description of these data elements is given later in this chapter.

~~This section contains general information about the project.~~

GENERAL INFORMATION

HERS Field Verification/Diagnostic Testing Required for Compliance	**Yes**
Conditioned Floor Area:	1384 ft^2
Average Ceiling Height	10.2 ft.
Building Type:	Single Family Detached
Building Front Orientation:	15 ~~0~~deg (North)
Glazing Area as % of Floor Area	14.4%
Average Fenestration U-factor	0.52
Average Fenestration SHGC	0.60
Number of Dwelling Units:	1
Number of Stories:	~~1~~2
Floor Construction Type:	Slab on grade
Number of Conditioned Zones:	2
Total Conditioned Volume:	11072 cf
Conditioned Slab Floor Area:	1384 ft^2
Total Conditioned Floor Area:	1384 ft^2

- *HERS Field Verification/Diagnostic Testing Required For Compliance (yes or no).* At the very beginning of the Certificate of Compliance, this provides a prominent notification when compliance with the performance standards requires HERS Rater field verification or diagnostic testing.

~~1.2.2~~1.2 *Optional Modeling Capabilities*

Candidate ACMs may have more capabilities than the minimum required. ACMs can be approved for use with none, a few, or all of the optional capabilities. The following optional capabilities are recognized for residential ACMs:

- Gas-~~Fired Heat Pumps~~ Absorption Cooling

Table R2-1 – HVAC Heating Equipment Descriptors

~~GasHeatPump~~	~~Heating side of a gas-fired heat pump. Two efficiencies, a COP for the gas portion and a COP for the electric portion. Descriptors expressed as COPheatinggas/COPheatingelectric.~~

Table R2-2 – HVAC Cooling Equipment Descriptors

GasCooling	~~Cooling side of a gas engine driven heat pump or air conditioner and~~ Gas absorption cooling. Two descriptors ~~efficiencies~~, COP95, the rated ~~a~~ COP for the gas portion and PPC, the parasitic electric energy at rated conditions in Watts.~~a COP for the electric portion. Descriptors expressed as COPcoolingas / COPcoolingelectric~~.

~~3.7.1~~ 3.6.3 Heating Equipment

Proposed Design.
The gas heating system type shall also be identified: ~~and if it is a~~ central gas furnace~~;~~ ~~or gas heat pump system,~~ or ~~a~~ non-central gas furnace system.

4.7.1 Cooling System Energy

The reference ACM calculates the hourly cooling electricity consumption in kWh using Equation R4-35. In this equation, the energy for the air handler fan and the electric compressor or parasitic power for the outdoor unit of a gas ~~fired~~ absorption air conditioner are combined. The ACM calculates the hourly cooling gas consumption in therms using Equation 4-36 ~~fan and the compressor are combined~~.

Equation R4-35

$$AC_{kWh} = \frac{Fan_{Wh} + Comp_{Wh} + PPC_{Wh}}{1{,}000}$$

Equation 4-36

$$AC_{therms} = \frac{Absorption_{Btu}}{100{,}000}$$

where

AC_{kWh}= Air conditioner kWh of electricity consumption for a particular hour of the simulation. This value is calculated for each hour, combined with the TDV multipliers, and summed for the year.

Fan_{Wh}= Fan watt-hours for a particular hour of the simulation. See Equation R4-49.

$Comp_{Wh}$= Compressor watt-hours for a particular hour of the simulation. This is calculated using Equation R4-37.

PPC_{Wh}= Parasitic Power watt-hours for gas ~~fired~~ absorption air conditioners for a particular hour of the simulation. This is calculated using Equation R4-44 ~~X2~~

AC_{therms}= Air conditioner therms of gas consumption for a particular hour of the simulation. This value is calculated for each hour, combined with the TDV multipliers, and summed for the year.
$Absorption_{Btu}$= Gas consumption in Btu for absorption air conditioners for a particular hour of the simulation. This is calculated using Equation R4-43 ~~X1~~

Gas Absorption systems

To determine the electric and gas energy use of gas ~~fired~~ absorption air conditioning systems the algorithms described in this section should be used.

Equation R4-43 $$Absorption_{Btu} = \frac{CLoad_{hr} \times CDEM_{hr}}{?_{seasonal,dist} \times AE_t} + \frac{Fanwhx3.413}{AE_t}$$

Equation R4-44 $$PPC_{wh} = \frac{CLoad_{hr} \times CDEM_{hr}}{?_{seasonal,dist} \times PE_t}$$

where:

$CLoad_{hr}$ = Space sensible cooling load for the hour from the ACM simulation (Btu).

$CDEM_{hr}$ = Cooling Duct Efficiency Multiplier for the hour calculated from Equation R4-66. This value varies with each hour depending on outdoor temperature. A value of 1.00 is used unless the supply ducts are located in the attic.

$\eta_{seasonal,\ dist}$ = Seasonal distribution system efficiency for the cooling season from Equation R4-55.

AE_t = Sensible energy efficiency of the gas ~~fired~~ absorption~~ber~~ system at a particular outdoor dry bulb temperature. This is calculated Equation R4-45 ~~52~~ using below.

PE_t = Sensible energy efficiency of the parasitic power at a particular outdoor dry bulb temperature. This is calculated using Equation R4-46 ~~53~~below.

Fan_{wh} = Fan watts this hour. This is calculated using Equation R4-.

Equation R4-45 $$AE_t = COP_t \times (0.88 + 0.00156 \times (DB_t - 95))$$

Equation R4-46 $$PE_t = PEER_t \times (0.88 + 0.00156 \times (DB_t - 95))$$

Where

DB_t = Outdoor dry bulb temperature taken from the CEC weather file.

COP_t = COP (coefficient of performance for the gas consumption) of the gas absorption~~ber~~ system at a particular dry bulb temperature calculated using Equation R-47 ~~54~~.

$PEER_t$ = PEER (parasitic electricity energy efficiency for the ~~outdoor~~ gas absorption~~ber~~ system) at a particular outdoor dry bulb temperature calculated using Equation R4-48 ~~X6~~

Equation R4-47

DB_t < 83 ºF	COP_t = COP82
83 < DB_t < 95	COP_t = COP82 + ((DB_t - 82)*(COP95 - COP82) / 13)
DB_t > 94	COP_t = COP95 - (DB_t - 95) * 0.00586

Equation R4-48

DB_t < 83 ºF	$PEER_t$ = PEER82
83 < DB_t < 95	$PEER_t$ = PEER82 + ((DB_t - 82)*(PEER95 - PEER82) / 13)
DB_t > 94	$PEER_t$ = PEER95 - (DB_t - 95) * 0.00689

Where

CAP95= Rated capacity of the gas ~~fired~~ absorption~~ber~~ system, Btuh, input by the compliance user

COP95 = Rated COP of the gas ~~fired~~ absorption~~ber~~ system, input by compliance user

PPC = Parasitic electric energy ~~ratio~~ at rated conditions, W, input by compliance user

COP82 = COP95 * 1.056

PEER95= Cap95 / PPC, BTU / Wh

PEER82= PEER95 * 1.056

Table R6-1 – Summary of the Optional Space Conditioning Tests

~~OC~~	~~9~~	~~A~~	~~3, 9, 12, 14, 16~~	~~**Gas Engine Driven Cooling**. Replace the basecase cooling system with an engine driven gas fired cooling system with a COP of 2.27. Produces a positive compliance margin.~~	~~**Fenestration U-factor**. Increase the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.~~
OC	9 ~~10~~	A	3, 9, 12, 14, 16	**Gas Absorption Cooling.** Replace the basecase cooling system with an absorption gas cooling system with a COP of 3.3. Produces a positive compliance margin	**Fenestration U-factor**. Increase the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.

6.2.8 Gas ~~Fired~~ Cooling

Measure Description

Gas ~~Fired~~ cooling provides an opportunity to reduce peak electric demand. ~~Two types of systems are available for residential applications: engine driven and absorption. With gas engine driven cooling the electric motor that would normally power the compressor is replaced by a gas reciprocating engine.~~ With gas absorption, a chemical process is used to provide cooling.

As a minimum capability, ACMs must be able to accept a COP input, report the use of gas ~~fired~~ cooling in the *Special Features and Modeling Assumptions* section of the reports. The ACM user must also attach supporting calculations or worksheets of Commission approved methods.

Algorithms and Modeling Assumptions

Test Description

To determine the accuracy of modeling gas cooling ~~fired heat pumps~~ the ACM vendor shall perform the test listed in *Table R6-1*. ~~One test is for engine driven gas cooling and the other for absorption. In both cases, t~~ The passing and failing solutions are determined by varying the fenestration U-factor.

Optional Capabilities Tests (OC)

~~Test OC09 Gas Engine Driven Cooling~~

~~Label~~	~~Space Conditioning TDV Energy (kBtu/ft²/y)~~		~~Fenestration U-Factor Solution~~		~~ACM Filenames~~	
	~~Passing Case~~	~~Failing Case~~	~~Passing Case~~	~~Failing Case~~	~~Passing Case~~	~~Failing Case~~
~~OC09A03~~						
~~OC09A09~~						
~~OC09A12~~						
~~OC09A14~~						
~~OC09A16~~						

V.1.2 Test OC9 ~~10~~ – Gas Absorption Cooling

Label	Space Conditioning TDV Energy (kBtu/ft²/y)		Fenestration U-Factor Solution		ACM Filenames	
	Passing Case	Failing Case	Passing Case	Failing Case	Passing Case	Failing Case
OC9 ~~10~~ A03						
OC9 ~~10~~ 10A09						
OC9 ~~10~~ 10A12						
OC9 ~~10~~ 10A14						
OC9 ~~10~~ 10A16						

~~3.7~~3.6 *Heating and Cooling System*

3.6.1 System Type

Proposed Design. ACMs ~~must~~shall require the user to enter simple heating and cooling seasonal efficiencies that ~~are used to~~ characterize basic package single zone HVAC systems used to heat and/or cool the modeled building. ACMs ~~must~~shall be able to distinguish what fuel is being used to heat the building and what fuel is used to cool the dwelling. This may be based on direct user input or indirectly determined from the user's selection of HVAC equipment types. ACMs ~~must~~shall require the user to enter the type of distribution system that is used in the proposed design.

For buildings using more than one system type, equipment type, or fuel type and the types do not serve the same floor area the user shall either zone the building or enter the floor area served by each type and the ACM shall weight the load to each type by zone or floor area.

For floor areas served by more than one heating system, equipment, or fuel type the user of the program shall specify which system, equipment, and fuel type satisfies the heating loads.

For floor areas served by more than one cooling system, equipment, or fuel type the user of the program shall specify which system, equipment, and fuel type satisfies the cooling loads.

Standard Design. The standard heating and cooling system for central HVAC systems is a single zone system with ducts in the attic. The standard heating and cooling system for non-central HVAC systems is an unducted system.

For buildings using more than one system, equipment, or fuel type where each conditions a different floor area within the building, the *Standard Design* shall use the weighted allocation of loads to each system, equipment, or fuel type as used for the *Proposed Design*.

For floor areas in the proposed design served by more than one system, equipment, or fuel type, loads for those floor areas shall be assumed to be satisfied in the *Standard Design* as specified in section 3.6.3 and 3.6.4 for each system, equipment, and fuel type the user specifies in the proposed design.

~~3.7.1~~ 3.6.3 *Heating Equipment*

Proposed Design. ACMs ~~must~~ shall be able to model the basic types of heating equipment and the efficiency metrics listed in the Appliance Efficiency Regulations for Gas Fired Central Furnaces, Wall Furnaces, Floor Furnaces and Room Heaters, except for combined hydronic space and water heating systems, which is an optional capability.

VI. RH4.3.4 Kneewalls and Skylight Shafts

- For steel-framed kneewalls and skylight shafts, external surfaces of steel studs ~~must~~ shall be covered with batts or rigid foam unless otherwise specified on the CF-1R using correct U-factors from Joint Appendix IV, Table IV-11 (or U-factors approved by the CEC Executive Director) ~~and documented by a form 3R generated by EZFRAME~~.

VI.1 RH10. Certificate Availability

The Insulation Certificate (IC-1) and Installation Certificate (CF-6R), with insulation material bag labels or coverage charts attached), signed by the insulation installer, shall be available on the building site for each of the HERS rater's verification inspections. Note: The HERS rater cannot verify compliance credit without these completed forms.

VI.2 CF-6R & CF-4R Insulation Installation Quality Certificate

NOTE: THE FOLLOWING ~~FORMS PROVIDED FOR~~ INFORMATION IS REQUIRED TO BE DOCUMENTED IN A FORMAT SPECIFIED BY THE COMMISSION. ~~IT WILL LIKELY BE INCULEDE IN THE RESIDENTIAL CONSERVATION MANUAL AND NOT IN THE ACM MANUAL.~~

NONRESIDENTIAL CHANGES

Section 100

(a) **Buildings Covered.** The provisions of Title 24, Part 6, apply to all buildings:

1. That are of Occupancy Group A, B, E, F, H, M, R, ~~or~~ S, or U; and
2. For which an application for a building permit or renewal of an existing permit is filed (or is required by law to be filed) on or after the effective date of the provisions, or which are constructed by a governmental agency; and
3. That are:
   A. Unconditioned, ~~D~~Indirectly or ~~in~~directly conditioned by mechanical heating or mechanical cooling or process spaces; or
   B. Low-rise residential buildings that are heated with a wood heater or another non-mechanical heating system.~~; or~~
   ~~C. Semiconditioned nonresidential occupancies.~~

Section 100

(b) **Parts of Buildings Regulated**. The provisions of Title 24, Part 6, apply to the building envelope, space-conditioning systems, water-heating systems, and lighting systems of buildings covered by Section 100 (a) as set forth in TABLE 100-A TABLE 100-A ~~Table 1-A~~.

TABLE 100-A APPLICATION OF STANDARDS

Occupancies	Application	Mandatory	Prescriptive	Performance	Additions/Alterations
General Provisions		100, 101, 102, 110, 111			
Nonresidential, High-Rise Residential, And Hotels/Motels	General	140	142	141	149
	Envelope (conditioned)	116, 117, 118	143		
	Envelope (unconditioned, process spaces))	~~116, 117, 118~~	143 (c)		
	HVAC (conditioned)	112, 115, 120-125	144		
	Water Heating (conditioned)	113, 123	145		
	Indoor Lighting (conditioned, unconditioned, process spaces)	119, 130, 131	143 (c), 146		
	Outdoor Lighting	119, 130, 132	147		
Signs	Indoor and Outdoor	132	148		
Low-Rise Residential	General	150	151 (a, f)	151 (a-e)	152
	Envelope (conditioned)	116, 117, 118, 150 (a-g, l)			
	HVAC (conditioned)	112, 115, 150 (h, I, m)			
	Water heating (conditioned)	113, 150 (j)			
	Indoor Lighting (conditioned and parking garages)	119(d), 150 (k)			
	Outdoor Lighting	119(d), 150 (k)			

Section 100 (e) 2

C. ~~Semiconditioned~~ Uncondtioned nonresidential buildings and process spaces. Sections 119, 130 through 132, 143 (c), ~~and~~ 146, 147 and 148 apply to all newly constructed unconditioned buildings and process spaces within the scope of Section 100 (a).

Section 101 (b)

DIRECTLY CONDITIONED SPACE is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/(hr.×ft.^{2}), or is provided with mechanical cooling that has a capacity exceeding 5 Btu/(hr.×ft.^{2}), unless the space-conditioning system is designed for a process space.~~and thermostatically controlled to maintain a process environment temperature less than 55°F or to maintain a process environment temperature greater than 90°F for the whole space that the system serves, or unless the space-conditioning system is designed and controlled to be incapable of operating at temperatures above 55°F or incapable of operating at temperatures below 90°F at design conditions.~~ (See "Process space")

PROCESS SPACE is a space that is thermostatically controlled to maintain a process environment temperature less than 55 ^{o}F or to maintain a process environment temperature greater than 90 ^{o}F for the whole space that the system serves, or that is a space with a space-conditioning system designed and controlled to be incable of operating at temperatures above 55 ^{o}F or incapable of operating at temperatures below 90 ^{o}F at design conditions.

Nonresidential Chiller Efficiency

Section 100 (b) Definitions

NONSTANDARD PART LOAD VALUE (NPLV) is a single-number part-load efficiency figure of merit for chillers referenced to conditions other than IPLV conditions. (See "Integrated Part Load Value")

TABLE 112-D~~C3~~ WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	**Size Category**	~~**Efficiency prior to 10/29/2001**~~	**Efficiency ~~as of 10/29/2001~~**	**Test Procedure**
Air Cooled, With Condenser, Electrically Operated	< 150 Tons	~~2.70 COP~~ ~~2.80 IPLV~~	2.08 COP ~~2.80~~ 3.05 IPLV	ARI 550/590 ~~or~~ ~~ARI 590~~ ~~As appropriate~~
	≥ 150 Tons	~~2.50 COP~~ ~~2.50 IPLV~~		
Air Cooled, Without Condenser, Electrically Operated	All Capacities	~~3.10 COP~~ ~~3.20 IPLV~~	3.10 COP ~~3.10~~ 3.45 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	~~3.80 COP~~ ~~3.90 IPLV~~	4.20 COP ~~4.65~~ 5.05 IPLV	ARI 550/590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 Tons	~~3.80 COP~~ ~~3.90 IPLV~~	4.45 COP ~~4.50~~ 5.20 IPLV	ARI 550/590 ~~or~~ ~~ARI 590~~ ~~As appropriate~~
	≥ 150 Tons and < 300 Tons	~~4.20 COP~~ ~~4.50 IPLV~~	4.90 COP ~~4.95~~ 5.60 IPLV	
	≥ 300 Tons €	~~5.20 COP~~ ~~5.30 IPLV~~	5.50 COP ~~5.60~~ 6.15 IPLV	
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	~~3.80 COP~~ ~~3.90 IPLV~~	5.00 COP ~~5.00~~ 5.25 IPLV	ARI 550/590
	≥ 150 Tons and < 300 Tons	~~4.20 COP~~ ~~4.50 IPLV~~	5.55 COP ~~5.55~~ 5.90 IPLV	
	≥ 300 Tons €	~~5.20 COP~~ €	6.10 COP ~~6.10~~ 6.40 IPLV	
Air Cooled Absorption Single Effect	All Capacities	~~N/A~~	0.60 COP	
Water Cooled Absorption Single Effect	All Capacities	~~N/A~~	0.70 COP	
Absorption Double Effect, Indirect-Fired	All Capacities	~~N/A~~ ~~N/A~~	1.00 COP 1.05 IPLV	ARI 560
Absorption Double Effect, Direct-Fired	All Capacities	~~N/A~~ ~~N/A~~	1.00 COP 1.00 IPLV	
Water Cooled Gas Engine Driven Chiller	All Capacities		1.2 COP 2.0 IPLV	ANSI Z21.40.4

TABLE 112-H~~C8~~ COPS ~~AND IPLVS~~ FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS

Centrifugal Chillers < 150 Tons **COPstd = ~~5.4~~ 5.0**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP ~~and IPLV (IPLV=COP)~~					
46	75	29	~~6.00~~ 5.58	~~6.27~~ 5.83	~~6.48~~ 6.03	~~6.80~~ 6.32	~~7.03~~ 6.54	~~7.20~~ 6.70
45	75	30	~~5.92~~ 5.50	~~6.17~~ 5.74	~~6.37~~ 5.92	~~6.66~~ 6.19	~~6.87~~ 6.38	~~7.02~~ 6.53
44	75	31	~~5.84~~ 5.42	~~6.08~~ 5.65	~~6.26~~ 5.82	~~6.53~~6.07	~~6.71~~6.24	~~6.86~~6.37
43	75	32	~~5.75~~ 5.35	~~5.99~~ 5.57	~~6.16~~ 5.72	~~6.40~~ 5.95	~~6.58~~6.11	~~6.71~~6.23
42	75	33	~~5.67~~ 5.27	~~5.90~~ 5.49	~~6.06~~ 5.64	~~6.29~~ 5.85	~~6.45~~6.00	~~6.57~~6.11
41	75	34	~~5.59~~ 5.19	~~5.82~~ 5.41	~~5.98~~ 5.56	~~6.19~~ 5.75	~~6.34~~ 5.89	~~6.44~~ 5.99
46	80	34	5.19	5.41	5.56	5.75	5.89	5.99
40	75	35	~~5.50~~ 5.11	~~5.74~~ 5.33	~~5.89~~ 5.48	~~6.10~~ 5.67	~~6.23~~ 5.79	~~6.33~~ 5.88
~~46~~	~~80~~	~~34~~	~~5.59~~	~~5.82~~	~~5.98~~	~~6.19~~	~~6.34~~	~~6.44~~
45	80	35	~~5.50~~5.11	~~5.74~~5.33	~~5.89~~5.48	~~6.10~~5.67	~~6.23~~5.79	~~6.33~~5.88
44	80	36	~~5.41~~ 5.03	~~5.66~~ 5.26	~~5.81~~ 5.40	~~6.01~~ 5.58	~~6.13~~ 5.70	~~6.22~~ 5.79
43	80	37	~~5.31~~ 4.94	~~5.57~~ 5.18	~~5.73~~ 5.32	~~5.92~~ 5.50	~~6.04~~ 5.62	~~6.13~~ 5.70
42	80	38	~~5.21~~ 4.84	~~5.48~~ 5.10	~~5.64~~ 5.25	~~5.84~~ 5.43	~~5.95~~ 5.53	~~6.04~~ 5.61
41	80	39	~~5.09~~ 4.73	~~5.39~~ 5.01	~~5.56~~ 5.17	~~5.76~~ 5.35	~~5.87~~ 5.46	~~5.95~~ 5.53
46	85	39	4.73	5.01	5.17	5.35	5.46	5.53
40	80	40	~~4.96~~ 4.62	~~5.29~~4.92	~~5.47~~ 5.09	~~5.67~~ 5.27	~~5.79~~ 5.38	~~5.86~~ 5.45
~~46~~	~~85~~	~~39~~	~~5.09~~	~~5.39~~	~~5.56~~	~~5.76~~	~~5.87~~	~~5.95~~
45	85	40	~~4.96~~ 4.62	~~5.29~~4.92	~~5.47~~ 5.09	~~5.67~~ 5.27	~~5.79~~ 5.38	~~5.86~~ 5.45
44	85	41	~~4.83~~ 4.49	~~5.18~~ 4.82	~~5.40~~ 5.00	~~5.59~~ 5.20	~~5.71~~ 5.30	~~5.78~~ 5.38
43	85	42	~~4.68~~ 4.35	~~5.07~~ 4.71	~~5.28~~ 4.91	~~5.50~~ 5.12	~~5.62~~ 5.23	~~5.70~~ 5.30
42	85	43	~~4.51~~ 4.19	~~4.94~~ 4.59	~~5.17~~ 4.81	~~5.41~~ 5.03	~~5.54~~ 5.15	~~5.62~~ 5.22
41	85	44	~~4.33~~ 4.02	~~4.80~~ 4.46	~~5.05~~ 4.70	~~5.31~~ 4.94	~~5.45~~ 5.06	~~5.53~~ 5.14
40	85	45	~~4.13~~ 3.84	~~4.65~~ 4.32	~~4.92~~ 4.58	~~5.21~~ 4.84	~~5.35~~ 4.98	~~5.44~~ 5.06
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)~~2~~ ^{2} - 0.000045595(X)~~3~~ ^{3}

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 112-~~IC9~~ COPS ~~AND IPLVS~~ FOR NON-STANDARD CENTRIFUGAL CHILLERS > 150 TONS, £ 300 TONS

Centrifugal Chillers > 150 Tons, ≤ 300 Tons **COP_{std} = 5.55**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP ~~and IPLV (IPLV=COP)~~					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.9	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
~~46~~	~~80~~	~~34~~	~~5.74~~	~~5.98~~	~~6.14~~	~~6.36~~	~~6.51~~	~~6.62~~
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
~~46~~	~~85~~	~~39~~	~~5.23~~	~~5.54~~	~~5.71~~	~~5.91~~	~~6.03~~	~~6.11~~
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)~~2~~ ^{2} - 0.000045595(X)~~3~~ ^{3}

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 112-J~~C10~~ COPS ~~AND IPLVS~~ FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 TONS

Centrifugal Chillers > 300 Tons **COP_{std} = 6.1**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP ~~and IPLV (IPLV=COP)~~					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
~~46~~	~~80~~	~~34~~	~~6.33~~	~~6.60~~	~~6.77~~	~~7.02~~	~~7.18~~	~~7.30~~
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
~~46~~	~~85~~	~~39~~	~~5.77~~	~~6.11~~	~~6.30~~	~~6.52~~	~~6.65~~	~~6.74~~
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692$(X)^2$ - 0.000045595$(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 112-K IPLV/NPLV FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS

Centrifugal Chillers < 150 Tons **IPLVstd = 5.25**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required IPLV/NPLV					
46	75	29	5.84	6.10	6.30	6.61	6.84	7.00
45	75	30	5.75	6.00	6.19	6.47	6.68	6.83
44	75	31	5.67	5.91	6.08	6.34	6.53	6.67
43	75	32	5.59	5.82	5.99	6.23	6.39	6.52
42	75	33	5.51	5.74	5.90	6.12	6.27	6.39
41	75	34	5.43	5.66	5.81	6.02	6.16	6.26
46	80	34	5.43	5.66	5.81	6.02	6.16	6.26
40	75	35	5.35	5.58	5.73	5.93	6.06	6.15
45	80	35	5.35	5.58	5.73	5.93	6.06	6.15
44	80	36	5.26	5.50	5.65	5.84	5.96	6.05
43	80	37	5.16	5.42	5.57	5.76	5.87	5.96
42	80	38	5.06	5.33	5.49	5.67	5.79	5.87
41	80	39	4.95	5.24	5.41	5.60	5.71	5.78
46	85	39	4.95	5.24	5.41	5.60	5.71	5.78
40	80	40	4.83	5.14	5.32	5.52	5.63	5.70
45	85	40	4.83	5.14	5.32	5.52	5.63	5.70
44	85	41	4.69	5.04	**5.25** [c]	5.43	5.55	5.62
43	85	42	4.55	4.93	5.13	5.35	5.47	5.54
42	85	43	4.38	4.80	5.03	5.26	5.38	5.46
41	85	44	4.21	4.67	4.91	5.17	5.30	5.38
40	85	45	4.01	4.52	4.79	5.06	5.20	5.29
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All values shown are NPLV except at conditions of 3 gpn/ton and 41 °F LIFT which is IPLV.

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 112-L IPLV/NPLV FOR NON-STANDARD CENTRIFUGAL CHILLERS > 150 TONS, < 300 tons

Centrifugal Chillers > 150 Tons, < 300 Tons **IPLVstd = 5.9**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required IPLV/NPLV					
46	75	29	6.58	6.87	7.11	7.46	7.71	7.90
45	75	30	6.49	6.76	6.98	7.30	7.53	7.70
44	75	31	6.40	6.66	6.86	7.15	7.36	7.52
43	75	32	6.31	6.56	6.75	7.02	7.21	7.35
42	75	33	6.22	6.47	6.65	6.90	7.07	7.20
41	75	34	6.13	6.38	6.55	6.79	6.95	7.06
46	80	34	6.13	6.38	6.55	6.79	6.95	7.06
40	75	35	6.03	6.29	6.46	6.68	6.83	6.94
45	80	35	6.03	6.29	6.46	6.68	6.83	6.94
44	80	36	5.93	6.20	6.37	6.58	6.72	6.82
43	80	37	5.82	6.11	6.28	6.49	6.62	6.72
42	80	38	5.71	6.01	6.19	6.40	6.53	6.62
41	80	39	5.58	5.91	6.10	6.31	6.44	6.52
46	85	39	5.58	5.91	6.10	6.31	6.44	6.52
40	80	40	5.44	5.80	6.00	6.22	6.35	6.43
45	85	40	5.44	5.80	6.00	6.22	6.35	6.43
44	85	41	5.29	5.68	**5.90** [c]	6.13	6.26	6.34
43	85	42	5.13	5.55	5.79	6.03	6.16	6.25
42	85	43	4.94	5.41	5.67	5.93	6.07	6.16
41	85	44	4.74	5.26	5.54	5.82	5.97	6.07
40	85	45	4.52	5.09	5.40	5.71	5.87	5.97
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All values shown are NPLV except at conditions of 3 gpn/ton and 41 °F LIFT which is IPLV.

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 112-M IPLV/NPLV FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 tons

Centrifugal Chillers > 300 Tons **IPLVstd = 6.4**								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required IPLV/NPLV					
46	75	29	7.15	7.47	7.72	8.10	8.37	8.58
45	75	30	7.05	7.35	7.58	7.93	8.18	8.36
44	75	31	6.95	7.23	7.45	7.77	8.00	8.16
43	75	32	6.85	7.13	7.33	7.63	7.83	7.98
42	75	33	6.75	7.03	7.22	7.49	7.68	7.82
41	75	34	6.65	6.93	7.12	7.37	7.55	7.67
46	80	34	6.65	6.93	7.12	7.37	7.55	7.67
40	75	35	6.55	6.83	7.01	7.26	7.42	7.54
45	80	35	6.55	6.83	7.01	7.26	7.42	7.54
44	80	36	6.44	6.73	6.92	7.15	7.30	7.41
43	80	37	6.32	6.63	6.82	7.05	7.19	7.30
42	80	38	6.20	6.53	6.72	6.95	7.09	7.19
41	80	39	6.06	6.42	6.62	6.85	6.99	7.08
46	85	39	6.06	6.42	6.62	6.85	6.99	7.08
40	80	40	5.91	6.30	6.52	6.76	6.89	6.98
45	85	40	5.91	6.30	6.52	6.76	6.89	6.98
44	85	41	5.75	6.17	**6.40** [c]	6.66	6.79	6.89
43	85	42	5.57	6.03	6.28	6.55	6.70	6.79
42	85	43	5.37	5.88	6.16	6.44	6.59	6.69
41	85	44	5.15	5.71	6.01	6.33	6.49	6.59
40	85	45	4.91	5.53	5.86	6.20	6.37	6.48
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature (°F) – Leaving Chilled Water Temperature (°F)

[b] Condenser DT = Leaving Condenser Water Temperature (°F) – Entering Condenser Water Temperature (°F)

[c] All values shown are NPLV except at conditions of 3 gpn/ton and 41 °F LIFT which is IPLV.

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

Nonresidential and Residential Ducts

Section 124

(a) **CMC Compliance**. All air distribution system ducts and plenums, including, but not limited to, building cavities, mechanical closets, air-handler boxes and support platforms used as ducts or plenums, shall be installed, sealed and insulated to meet the requirements of the ~~1998~~ 2001 CMC Sections 601, 602, 603, 604, 605, and Standard 6-~~3~~5, incorporated herein by reference. ~~Portions conveying conditioned air shall either be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 604) or be enclosed entirely in conditioned space.~~ Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A, or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

Portions of supply-air and return-air ducts ~~ductwork~~ conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum installed level of R-8:

1. Outdoors, or
2. In a space between the roof and an insulated ceiling, or
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or
4. In an unconditioned crawlspace; or
5. In other unconditioned spaces.

Portions of supply-air ducts ~~ductwork~~ that are not in one of these spaces shall be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 605) or be enclosed in conditioned space.

~~(g) **Porous Inner Core Flex Duct.** Flexible ducts having porous inner cores shall not be used.~~

Section 150

(m) **Air-distribution System Ducts, Plenums, and Fans.**

1. **CMC compliance.** All air-distribution system ducts and plenums, including, but not limited to, mechanical closets and air-handler boxes, shall be installed, sealed and insulated to meet the requirements of the ~~1998~~ CMC Sections 601, 602, 603, ~~and~~ 604, 605 and Standard 6-5~~3~~, incorporated herein by reference. Portions ~~conveying conditioned air~~ of supply-air and return-air ducts and plenums shall either be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 605) or be enclosed entirely in conditioned space. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, ~~aerosol sealant,~~ or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B or aerosol sealant that meets the requirements of UL 723. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used. Building cavities, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross-sectional area of the ducts.

Nonresidential Cool Roofs

Section 118 (i)

3. Liquid applied roof~~ing products~~ coatings applied in the field as the top surface of a roof covering shall be applied at a minimum dry mil thickness of 20 mils across the entire roof surface, and meet the minimum performance requirements listed in Table 118-C.
EXCEPTION to Section 118 (i) 3: Permeable cement-based roof coatings shall be applied at a minimum dry mil thickness of 200 mils when installed over a rock or gravel surfaces and at a minimum dry mil thickness of 30 mils over other surfaces.

Section 143 (a)

1. **Exterior roofs and ceilings.** Exterior roofs and ceilings shall: ~~have either an installed insulation R-value no less than, or an overall assembly U-factor no greater than, the applicable value in~~
   A. For nonresidential buildings with low-sloped roofs, meet the requirements of ~~Section 118 (i) 3 and~~ either 118 (i) 1 or 118 (i) 2 and for liquid applied roof coatings, Section 118 (i) 3; and

      EXCEPTION to Section 143 (a) 1 A: Any roofing product with a minimum initial thermal emittance $\varepsilon_{initial}$ less than 0.75 when tested in accordance with CRRC-1, including but not limited to roof products with metallic surfaces, ~~with~~ if that roofing product has a minimum initial solar reflectance of 0.70 + 0.34 * (0.75 - $\varepsilon_{initial}$) when tested in accordance with CRRC-1.

Section 149 (b) 1

B. Replacements, recovering or recoating of the exterior surface of existing nonresidential low-sloped roofs shall meet Subsection i or ii where more than fifty percent of the roof or more than 2,000 square feet of roof, whichever is less, is being replaced, recovered or recoated.~~.~~
   i. The roof shall meet the requirements of ~~Section 118 (i) 3 and~~ either ~~or~~ 118 (i) 1 or 118 (i) 2; and for liquid applied roof coatings, Section 118 (i) 3, or
   ii. The building envelope, which has a roof replacement subject to this requirement, shall comply with Section 143 (b) 3, where
      a. the standard building has a solar reflectance which meets the requirements of Section 143 (a) 1 and the other terms in Equation 143-D correspond to the existing building at the time of the application of the permit, and

      b. the proposed building has either:

         a. the solar reflectance of the replacement roof product, as certified and labeled according to the requirements of Section 10-113 and the roof product meets the requirements of Section 118 (i) 3, or

         b. a solar reflectance of ~~0.30~~ 0.10 if the product has not been certified and labeled and/or does not meet the requirements of Section 118 (i) 3, and

         c. has the other improvements to the building envelope necessary to comply.

EXCEPTION to Section 149 (b) 1 B: Roof recoverings allowed by the CBC are not required to meet Section 149 (b) 1 B when all of the following occur:

1. The existing roof has a rock or gravel surface, and
2. The new roof has a rock or gravel surface, and
3. There is no removal of existing layers of roof coverings of more than fifty percent of the roof or more than 2,000 square feet of roof, whichever is less; and
4. There is no recoating with a liquid applied coating~~.~~; and
5. There is no installation of a recover board, rigid insulation or other rigid, smooth substrate to separate and protect the new roof recovering from the existing roof.

VI.3 SECTION 125 – ~~RESERVED~~. REQUIRED NONRESIDENTIAL MECHANICAL SYSTEM ACCEPTANCE

(a) **Air Distribution System Duct and Plenum Acceptance.** Before an occupancy permit is granted for a newly constructed building or space, or a new space-conditioning or ventilating system serving a building or space is operated for normal use, all air distribution system ducts and plenums serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Nonresidential ACM Manual. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.
2. Certifies that air distribution ducts and plenums meet the requirements of Section 124 (a) through Section 124 (j).
3. Certifies that air distribution ducts meet the requirements of Section 144 (k) for duct sealing to comply with the Prescriptive Approach or to comply with Section 141.

(b) **Economizer Acceptance**. Before an occupancy permit is granted for a newly constructed building or space, or a new space-conditioning system serving a building or space is operated for normal use, all economizers serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Nonresidential ACM Manual. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6, and
2. Certifies that the economizers meet the requirements of Section 144 (e) ~~1, 2 and 3~~ for economizers installed to comply with the Prescriptive Approach or to comply with Section 141.. ~~Economizers that are installed to meet the requirements of Ssction 141 or that are installed when the individual cooling fan system has a design supply capacity equal or less than 2,500 cfm and/or a total mechanical cooling capacity equal or less than 75,000 Btu/hr shall be certified to meet the requirements of Sections 144 (e) 1 A and B, 144 (e) 2 A and B, and 144 (e) 3.~~

EXCEPTION to Section 125(b): Air economizers installed by the HVAC ~~system~~ equipment manufacturer and certified to the commission as being factory calibrated and tested.

(c) **Variable Air Volume System Acceptance**. Before an occupancy permit is granted for a newly constructed building or space, or a new space-conditioning system serving a building or space is operated for normal use, all variable speed fans serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Nonresidential ACM Manual. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.
2. Certifies that the fans meet:
   A. the requirements of Section 144 (c) 2 for variable air volume systems installed to comply with the Prescriptive Approach; or
   B. the requirements of Sections 144 (c) 2 B, 144 (c) 2 C and 144 (c) 2 D for ~~V~~variable air volume systems installed to ~~comply with~~ comply with Section 141 ~~that have individual VAV~~

~~fans with motors 10 horsepower or larger shall be certified to meet the requirements of Section 144 (c) 2 B~~.

(d) **Hydronic System Controls Acceptance**. Before an occupancy permit is granted for a newly constructed building or space, or a new space-conditioning system serving a building or space is operated for normal use, all hydronic systems serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Nonresidential ACM Manual. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.
2. Certifies that the fans meet the requirements of Section 144 (~~i~~j) for hydronic systems installed to comply with the Prescriptive Approach or to comply with Section 141. ~~Hydronic systems installed to comply with Section 141 shall be certified to meet the requirements of each of the Sections 144 (i) 1 through 144 (i) 6 if they meet the conditions of the section.~~

Section 144 (e)

~~4. Economizer Acceptance. Before an occupancy permit is granted for a newly constructed building or space, or a new space conditioning system serving a building or space is operated for normal use, all economizers serving the building shall be certified as meeting the Acceptance Requirements for Code Compliance. A Certificate of Acceptance shall be submitted to the building department that:~~

~~A. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.~~

~~B. Certifies that the economizers meet the requirements of Section (e) 1, 2, and 3.~~

~~**EXCEPTION to Section 144 (e) 4:** Air economizers installed by the HVAC system manufacturer and certified to the commission as being factory calibrated and tested.~~

Section 144

~~(l) **Air Distribution System Duct and Plenum Acceptance.** Before an occupancy permit is granted for a newly constructed building or space, or a new space conditioning or ventilating system serving a building or space is operated for normal use, all distribution system ducts and plenums serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance. A Certificat of Acceptance shall be submitted to the building department that:~~

~~1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.~~

~~2. Certifies that air distribution ducts and plenums meet the requirements of Section 124 (a) through Section 124 (f).~~

Nonresidential Envelope

TABLE 143-A~~H —~~ PRESCRIPTIVE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS (including relocatable classrooms where manufacturer certifies use only in specific climate zone; not including~~except~~ high-rise residential buildings,~~and~~ guest rooms of hotel/motel buildings)

	CLIMATE ZONES									
	1, 16		**3-5**		**6-9**		**2, 10-13**		**14, 15**	
Roof/Ceiling										
U-factor	0.051		0.051		0.076		0.051		0.051	
R-value[1] ~~orU-factor~~	19~~0.057~~		19~~0.057~~		11~~0.078~~		19~~0.057~~		19~~0.057~~	
Wall										
R-value or										
U-factor	13		11		11		13		13	
Wood frame	0.102~~0.084~~		0.110~~0.092~~		0.110~~0.092~~		0.1024~~0.084~~		0.102~~0.084~~	
Metal frame	0.261~~0.182~~		0.268~~0.189~~		0.268~~0.189~~		0.261~~0.182~~		0.261~~0.182~~	
Metal building	0.113		0.123		0.123		0.113		0.113	
Mass/7.0≤ HC<15.0	~~0.340~~ 0.330 ~~3~~		0.430		0.430		0.430		0.430	
Mass/15.0≤HC	0.360		0.650		0.690		0.650		0.~~400~~410	
Other	0.~~084~~102		0.~~092~~110		0.~~092~~110		0.~~084~~102		0.~~084~~102	
Floor/Soffit										
R-value or										
U-factor	19		11		11		11		11	
Mass/7.0≤HC	0.~~097~~090		0.~~158~~139		0.139~~158~~		0.~~097~~090		0.139~~158~~	
Other	0.048~~0.050~~		0.071~~0.076~~		0.071~~0.076~~		0.071~~0.076~~		0.071~~0.076~~	
Windows										
U-factor[2]~~Relative solar heat gain~~	0.~~49~~47		0.~~81~~77		0.77~~81~~		0.4~~9~~7		0.4~~9~~7	
Relative solar heat gain	Non-North	North	Non-North	North	Non-North	North	Non-North	North	Non-North	North
0-10% WWR	0.49	0.72	0.61	0.61	0.61	0.61	0.47	0.61	0.46	0.61
11-20% WWR	0.43	0.49	0.55	0.61	0.61	0.61	0.36	0.51	0.36	0.51
21-30% WWR	0.43	0.47	0.41	0.61	0.39	0.61	0.36	0.47	0.36	0.47
31-40% WWR	0.43	0.47	0.41	0.61	0.34	0.61	0.31	0.47	0.31	0.40
Skylights										
U-factor[2] Glass w/Curb	~~0.99~~1.18		1.~~18~~42		1.42~~18~~		1.18~~0.99~~		1.18~~0.99~~	
Glass wo/Curb	0.~~57~~68		0.82~~68~~		0.82~~68~~		0.68~~57~~		0.68~~57~~	
Plastic w/Curb	~~0.87~~1.04		1.56~~30~~		1.56~~30~~		1.32~~10~~		1.32~~10~~	
SHGC Glass 0-2%	0.68		0.79		0.79		0.46		0.46	
SHGC Glass 2.1-5%	0.46		0.40		0.40		0.36		0.36	
SHGC Plastic 0-2%	0.77		0.79		0.77		0.77		0.71	
SHGC Plastic 2.1-5%	0.58		0.65		0.62		0.62		0.58	

Note: Construction assembly U-factors shall be calculated in accordance with Appendix IV.

[1] R-value cannot be used for compliance when roof has metal framing members or a metal deck unless additional rigid insulation is installed. See Section 143 (a) 1 C.

[2] U-factor adjustments are made to make the criteria consistent with revised NFRC rating procedures.

Section 144 (b)

4. **Outdoor design conditions**. Outdoor design conditions shall be selected from Joint Appendix II, which is based on data from the ASHRAE ~~publication SPCDX:~~ Climatic Data for Region X~~, Arizona, California, Hawaii, and Nevada, 1982~~. Heating design temperatures shall be no lower than the ~~temperature listed in the~~Heating Winter Median of Extremes ~~column~~values. Cooling design ~~dry bulb~~ temperatures shall be no greater than the ~~temperature listed in the Summer Design Dry Bulb 0.5~~ ~~1.0~~ 0.5 percent Cooling Dry Bulb and ~~column. Cooling design wet bulb temperatures shall be no greater than the temperature listed in the Summer Design~~ Mean Coincident Wet Bulb ~~0.5 percent column~~values.

EXCEPTION to Section 144 (b) 4: Cooling design temperatures for cooling towers shall be no greater than the 0.5 percent Cooling Design Wet bulb values.

Nonresidential ACM Approval Manual

2.5.3.8 Sizing Requirements

~~*Description:*~~

ACMs ~~must~~shall ~~determine~~ use outdoor weather design conditions for the building location from ~~the user entry for building location which in turn is selected from a list of cities~~ACM Joint Appendix II ~~. The Commission can provide software for city selection which is linked to a database of outdoor design conditions. The outdoor design data determined from the building location is used~~ for calculating design heating and cooling loads. In ~~certain~~ rural locations the user may enter a building location that is shown to have the most similar weather rather than ~~not~~ the closest city with the explicit approval of the local enforcement agency. The same city ~~must~~shall appear for all reports of building location and design weather data. The indoor design air temperature is based on the occupancy type using Table N2-5, Table N2-6, Table N2-7, and Table N2-8 ~~Table 2-4, 2-5, 2-6, or 2-7.~~.

ACMs ~~must~~shall perform design heating and cooling load calculations for each zone of the ~~standard~~ standard design and ~~proposed buildings~~proposed design. The design load methodology ~~must~~shall be consistent with the ASHRAE Handbook, ~~1997~~, Fundamentals Volume, or with another method approved by the Executive Director.

The reference method uses the following assumptions for design loads:

- *Fixed Design Assumptions by Occupancy*. User values as listed in Table N2-2 and Table N2-3 ~~*Tables 2-1 or 2-2*~~. Different occupancy schedules are used by the reference method to determine design loads. For cooling loads, lights, equipment/receptacles, and people are at 100% of full load while the building is occupied. For heating loads, these internal gains are 0% of full load at all hours of the day. The HVAC equipment operational hours and thermostat settings schedules ~~must~~shall be based on the selected occupancy type using the occupancy schedules shown in Table N2-5, Table N2-6, Table N2-7, and Table N2-8 ~~Table 2-4, 2-5, 2-6, or 2-7.~~.
- *Ventilation and Process Loads*. See applicable sections on ventilation and process loads.
- ~~*Outdoor Design Temperatures* for the building site location from ASHRAE publication SPCDX: Climate Data for Region X, Arizona, California, Hawaii and Nevada, 1982; latitude of building site location.~~
- *Outdoor Design Temperatures, Summer Daily Temperature Swing and Latitude.* The ACM ~~user must~~shall use ~~either be able to select a city from a list which automatically retrieves the ASHRAE Region X~~ the Heating Winter Median of Extremes temperature~~; and~~ ,and the ~~1.0%~~ 0.5 percent Cooling~~Summer~~ Dry-Bulb ~~(0.5%),~~ and Mean Coincident Wet-Bulb temperatures from ACM Joint Appendix II~~for the building site from a database~~; or the user ~~must~~shall be able to enter ~~the~~ these values ~~mentioned above~~ directly into the ACM.

The ACM ~~user must~~shall ~~also enter~~ use the daily temperature range for the design cooling day from the hourly weather file for the ~~and the latitude or have this value determined by~~ city ~~selection~~selected.

ACMs ~~must~~shall calculate, for both the ~~standard~~ standard design and proposed design~~s~~, heating and cooling loads and appropriate capacities for supply fans, cooling and heating equipment, hydronic pumps and heat rejection equipment. ACMs must be capable of calculating loads and capacities ~~as appropriate~~ for the five standard design systems. All assumptions for heating and cooling equipment and fan system sizing are documented below.

Cooling Loads

Description

The reference method calculates cooling loads for each fan system using the following assumptions:

- Peak cooling design day profiles ~~developed from ASHRAE SPCDX: Climate Data for Region X, Arizona, California, Hawaii and Nevada, 1982 design weather data~~from ACM Joint Appendix II ~~-~~for the city in which the building will be built. These profiles ~~must~~shall be developed using a method similar to the design day method of the reference computer program.
- All window interior and user-operated shading devices are ignored.
- Internal gains from occupants and receptacle loads are fixed at 100% of the values listed in Table N2-2 or Table N2-3 ~~Tables 2-1 or 2-2~~ while the building is occupied.
- Indoor dry-bulb temperatures are specified according to Table N 2-5, Table N 2-6, Table N 2-7, and Table N 2-8; ~~Tables; 2-4; 2-5; 2-6; or 2-7,~~ however, the ACM ~~must~~shall be able to calculate the indoor wet-bulb temperature using the occupancy information and the cooling coil characteristics.
- Outdoor design temperatures equal to those listed in the ~~Summer~~ ~~1.0~~ 0.5 Percent Cooling Design Dry Bulb ~~0.5%~~ and ~~the Summer Design~~Mean Coincident Wet-Bulb ~~0.5%~~ columns of ACM Joint Appendix II. For cooling tower design, temperatures listed in the Summer Design Wet-Bulb 0.5% columns ~~must~~shall be used.

BUILDING LOCATION DATA	is the specific outdoor design temperatures shown in Joint Appendix II used in calculating heating and cooling loads for the particular location of the building . For heating, the outdoor design temperature shall be the Winter Median of Extremes value. A higher temperature may be used, but lower values are not permitted. For low-rise residential buildings for cooling, the outdoor design temperatures shall be the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values. Lower temperatures may be used, but higher values are not permitted. Temperatures are interpolated from the 0.5% and 2.0% values in the ASHRAE publication, *Climatic Data for Region X,* 1982 edition and 1994 supplement (see Joint Appendix II). For nonresidential buildings, high-rise residential buildings and hotels/motels for cooling, the outdoor design temperatures shall be the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb. For cooling towers the outdoor design temperatures shall be the 0.5 percent Cooling Design Wet Bulb values. Lower temperatures may be used, but higher values are not permitted. If a building location is not listed, the local enforcement agency may determine the location for which outdoor design temperature data is available that is closest to the actual building site.

Table N2-2 – Occupancy Assumptions When Lighting Plans are Submitted for the Entire Building or When Lighting Compliance is not Performed

Occupancy Type	#people per 1000 ft²(1)	Sensible Heat per person(2)	Latent Heat per person(2)	Recept. Load W/ft²(3)	Hot Water Btu/h Per person	Lighting W/ft²(4)	Ventilation CFM/ft²(5)
Auditoriums (Note 8)	143	245	105	1.0	60	1.5	1.07
Convention Centers (Note 8)	136	245	112	0.96	57	1.3 ~~1.4~~	1.02 ~~1.03~~
Financial Institutions	10	250	250	1.5	120	1.1	0.15
~~Parking Garages~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~0.4~~	~~N/a~~
General Commercial and Industrial Work Buildings, High Bay	7	375	625	1.0	120	1.1 ~~1.2~~	0.15
General Commercial and Industrial Work Buildings, Low Bay	7	375	625	1.0	120	1.0	0.15
~~General Commercial and Industrial Work Buildings, Precision~~	~~7~~	~~375~~	~~625~~	~~1.0~~	~~120~~	~~1.5~~	~~0.15~~
Grocery Stores (Note 8)	29	252	225	0.91	113	1.5	0.22 ~~0.23~~
Hotel(6)	20	250	200	0.5	60	1.4	0.15
~~Commercial and~~ Industrial and Commercial Storage Buildings	5	268	403	0.43	108	0.7	0.15
Medical Buildings and Clinics~~/Clinical~~	10	250	213	1.18	110	1.1 ~~1.2~~	0.15
Office Buildings	10	250	206	1.34	106	1.1 ~~1.2~~	0.15
Religious ~~Worship, Auditorium~~Facilities (Note 8)	136	245	112	0.96	57	1.6 ~~1.8~~	1.03
~~Auditoriums~~	~~143~~	~~245~~	~~105~~	~~1.0~~	~~60~~	~~1.5~~	~~1.07~~
~~Convention Centers~~	~~136~~	~~245~~	~~112~~	~~0.96~~	~~57~~	~~1.3 1.4~~	~~1.03~~
~~Parking Garages~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~0.4~~	~~N/a~~
Restaurants (Note 8)	45	274	334	0.79	366	1.2	0.38
Retail and Wholesale Stores (Note 8)	29	252	224	0.94	116	1.5 ~~1.7~~	0.22 ~~0.23~~
Schools (Note 8)	40	246	171	1.0	108	1.2 ~~1.4~~	0.32
Theaters (Note 8)	130	268	403	0.54	60	1.3	0.98
All Others	10	250	200	1.0	120	0.6	0.15

(1) Most occupancy values are based on an assumed mix of sub-occupancies within the area. These values were ~~taken from~~ based on one half the maximum occupant load for exiting purposes in the ~~1994 Uniform Building Code, Table No. 10-A~~ CBC. Full value for design conditions. Full year operational schedules reduce these values by up to 50% for compliance simulations and full year test simulations.

(2) From Table 1~~3~~, p. 29.4~~28.8~~, ASHRAE 2001~~1997~~ Handbook of Fundamentals

(3) From Lawrence Berkeley Laboratory study. This value is fixed and includes all equipment that are plugged into receptacle outlets.

(4) From Table ~~1-M~~ 146-B of the Standards for the applicable occupancy.

(5) Developed from Section 121 and Table ~~1-F~~121-A of the Standards.

(6) ~~From Table N2.2~~Hotel uses values ~~from~~ for Hotel Function Area from Table N2.3.

(7) For retail and wholesale stores, the complete building method may only be used when the sales area is 70% or greater of the building area.

(8) For these occupancies, when the proposed design is required to have demand control ventilation by Section 121 (c) 3 the ventilation rate is the minimum that would occur at any time during occupied hours. Additional ventilation would be provided through demand controlled ventilation to maintain CO_2 levels according to Section 121 of the Standards.

Table N2-3 – Area Occupancy Assumptions When Lighting Plans are Submitted for Portions or for the Entire Building or When Lighting Compliance is not Performed

Sub-Occupancy Type [1]	#P~~p~~eople per 1000 ft^2 [2]	Sensible heat per person [3]	Latent heat per person [3]	Receptacle~~.~~ Load W/ft^2 [4]	Hot ~~w~~Water Btu/h~~-~~ Per person	Lighting W/ft^2 [5]	Ventilation CFM/ft^2 [6]
Auditorium (Note 10)	143	245	105	1.0	60	1.5 ~~2.0~~	1.07 ~~1.07~~ ~~0.15~~
Auto Repair ~~Workshop~~	10	275	475	1.0	120	1.1 ~~1.2~~	1.50
~~Bank/Financial Transactions Institution~~	~~10~~	~~250~~	~~250~~	~~1.5~~	~~120~~	~~1.2~~ ~~1.4~~	~~0.15~~
Bar, Cocktail Lounge and Casino (Note 10)	67	275	275	1.0	120	1.1	0.50 ~~1.50~~ ~~0.20~~
Barber and Beauty Shop	10	250	200	2.0	120	1.0	0.40
Classrooms, Lecture, Training, Vocational Room	50	245	155	1.0	120	1.2 ~~1.6~~	0.38
~~Courtrooms~~	~~25~~	~~250~~	~~200~~	~~1.5~~	~~120~~	~~1.1~~	~~0.19~~
Civic ~~Facilities~~ Meeting Space (Note 10)	25	250	200	1.5	120	1.3 ~~1.4~~	0.19
Commercial and ~~/~~Industrial Storage	3	275	475	0.2	120	0.6	0.15
Convention, Conference, Multi-purpose and Meeting Centers (Note 10)	67	245	155	1.0	60	1.4 ~~1.5~~	0.50 ~~0.50~~ ~~0.15~~
Corridors, Restrooms, Stairs, and Support Areas	10	250	250	0.2	0	0.6	0.15
Dining ~~Area~~ (Note 10)	67	275	275	0.5	385	1.1	0.50 ~~0.50~~ ~~0.15~~
Electrical, ~~and~~ Mechanical Room	3	250	250	0.2	0	0.7	0.15
Exercise, Center, ~~ing Centers and~~ Gymnasium	20	255	875	0.5	120	1.0	0.15
Exhibit, ~~Display Area and~~ Museum (Note 10)	67	250	250	1.5	60	2.0	0.50
Financial Transaction	10	250	250	1.5	120	1.2	0.15
~~General Commercial and /Industrial Work-General, High Bay~~	~~10~~	~~275~~	~~475~~	~~1.0~~	~~120~~	~~1.1~~ ~~1.2~~	~~0.15~~
~~General Commercial and /Industrial Work-General, Low Bay~~	~~10~~	~~275~~	~~475~~	~~1.0~~	~~120~~	1.0	~~0.15~~
~~General Commercial and /Industrial Work, -Precision [8]~~	~~10~~	~~250~~	~~200~~	~~1.0~~	~~120~~	~~1.3~~ ~~1.5~~	~~0.15~~
Dry Cleaning (Coin Operated)	10	250	250	3.0	120	0.9 ~~1.0~~	0.30
Dry Cleaning (Full Service Commercial)	10	250	250	3.0	120	0.9 ~~1.0~~	0.45
General Commercial and Industrial Work, High Bay	10	275	475	1.0	120	1. 1 ~~1.2~~	0.15
General Commercial and Industrial Work, Low Bay	10	275	475	1.0	120	1.0	0.15
General Commercial and Industrial Work, Precision	10	250	200	1.0	120	1. 3 ~~1.5~~	0.15
Grocery Sales ~~Area~~ (Note 10)	33	250	200	1.0	120	1.6	0.25 ~~0.25~~ ~~0.15~~
High-Rise Residential Living Spaces [9]	5	245	155	0.5	(7)	0.5	0.15
~~Housing, Public and Common Areas, Multi-family~~	~~10~~	~~250~~	~~250~~	~~0.5~~	~~120~~	~~1.0~~	~~0.15~~
~~Housing, Public and Common Areas, Dormitory, Senior Housing~~	~~10~~	~~250~~	~~250~~	~~0.5~~	~~120~~	~~1.5~~	~~0.15~~
Hotel Function Area (Note 10)	67	250	200	0.5	60	~~2.2~~ 1.5	0.50 ~~0.50~~ ~~0.15~~
Hotel/Motel Guest Room [9]	5	245	155	0.5	2800	0.5	0.15
Housing, Public and Common Areas, Multi-family	10	250	250	0.5	120	1.0	0.15
Housing, Public and Common Areas, Dormitory, Senior Housing	10	250	250	0.5	120	1.5	0.15
Kitchen, ~~and~~ Food Preparation	5	275	475	1.5	385	1.6 ~~1.7~~	0.15

Laundry	10	250	250	3.0	385	0.9	0.15
Library,~~ -~~ Reading Areas	20	250	200	1.5	120	1.2	0.15
Library,~~ -~~ Stacks	10	250	200	1.5	120	1.5	0.15
Lobby,~~ -~~ Hotel	10	250	250	0.5	120	1.1 ~~1.7~~	0.15
Lobby,~~ -~~ Main Entry ~~and Assembly~~	~~143~~10	250	250	0.5	60	1.5	~~1.07~~ 0.15
~~Lobby, - Office Reception/Waiting~~	~~10~~	~~250~~	~~250~~	~~0.5~~	~~120~~	~~1.1~~	~~0.15~~
Locker/~~ and ~~Dressing Room	20	255	475	0.5	385	0.8	0.15
Lounge, Recreation (Note 10)	67	275	275	1.0	60	1.1	0.50
Malls~~,~~ ~~Arcades,~~ and Atria~~um~~ (Note 10)	33	250	250	0.5	120	1.2	0.25
Medical and Clinical Care	10	250	200	1.5	160	1.2 ~~1.4~~	0.15
Office	10	250	200	1.5	120	1.2 ~~1.3~~	0.15
~~Parking Garages~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~N/a~~	~~0.4~~	~~N/a~~
Police Station and Fire Station	10	250	200	1.5	120	0.9	0.15
Religious Worship (Note 10)	143	245	105	0.5	60	1.5 ~~2.1~~	1.07 ~~1.07~~ ~~0.15~~
Retail Merchandise Sales,~~ and~~ Wholesale Showroom (Note 10)	33	250	200	1.0	120	1.7 ~~2.0~~	0.25 ~~0.25~~ ~~0.20~~
~~Smoking Lounge~~	~~67~~	~~275~~	~~275~~	~~0.5~~	~~120~~	~~1.1~~	~~1.50~~
Tenant Lease Space	10	250	200	1.5	120	1.0	0.15
~~Transportation Facilities~~	~~33~~	~~250~~	~~250~~	~~0.5~~	~~120~~	~~1.2~~	~~0.25~~
Theater, ~~(~~Motion Picture) (Note 10)	143	245	105	0.5	60	0.9	1.07 ~~1.07~~ ~~0.15~~
Theater, ~~(~~Performance) (Note 10)	143	245	105	0.5	60	1.4	1.07 ~~0.15~~ ~~1.07~~
Transportation Function (Note 10)	33	250	250	0.5	120	1.2	0.25
Waiting Area	10	250	250	0.5	120	1.1	0.15
All Other~~s~~	10	250	200	1.0	120	0.6	0.15
~~Unknown~~	~~10~~	~~250~~	~~200~~	~~1.0~~	~~120~~	~~0.8~~	~~0.15~~

(1) Subcategories of these suboccupancies are described in Section 2.~~3~~4.1.1 (Occupancy Types) of this manual.

(2) Values ~~taken from~~ based on one half the maximum occupant load for exiting purposes in the ~~1994 Uniform Building Code, Table No. 10-A~~ CBC. Full value for design conditions. Full year operational schedules reduce these values by up to 50% for compliance simulations and full year test simulations.

(3) From Table 1~~3~~, p. 29.4~~8.8~~, ASHRAE 2001~~1997~~ Handbook of Fundamentals.

(4) From Lawrence Berkeley Laboratory study. This value is fixed and includes all equipment that are plugged into receptacle outlets.

(5) From Table ~~1-N~~ 146-C of the Standards for the applicable occupancy. ACMs ~~must~~shall use this value for the standard building design when lighting compliance is performed for the zone or area in question.

(6) Developed from Section 121 and Table ~~1-F~~121-A of the Standards.

(7) Refer to residential water heating method.

(8) The use of this occupancy category is an exceptional condition that ~~must~~shall appear on the exceptional conditions checklist and thus requires special justification and documentation and independent verification by the local enforcement agency.

(9) For hotel/motel guest rooms and high-rise residential living spaces all these values are fixed and are the same for both the proposed design and the standard design. ACMs ~~must~~shall ignore user inputs that modify these assumptions for these two occupancies. Spaces in high-rise residential buildings other than living spaces, shall use the values for Housing, Public and Common Areas (either multi-family or senior housing).

(10) For these occupancies, when the proposed design is required to have demand control ventilation by Section 121 (c) 3 the ventilation rate is the minimum that would occur at any time during occupied hours. Additional ventilation would be provided through demand controlled ventilation to maintain CO_2 levels according to Section 121 of the Standards.

Table N2-4 – Schedule Types of Occupancies & Sub-Occupancies

Occupancy or Sub-Occupancy Type	Schedule
Atrium	Table 2-4 Nonresidential
Auditorium	Table 2-4: Nonresidential
Auto Repair ~~Workshop~~	Table 2-4: Nonresidential
~~Bank/Financial Transaction Institution~~	~~Table 2-4: Nonresidential~~
Bar, Cocktail Lounge and Casino	Table 2-4: Nonresidential
Barber and Beauty Shop	Table 2-4: Nonresidential
Classrooms, Lecture, Training, Vocational Room	Table 2-4: Nonresidential
~~Courtrooms~~	~~Table 2-4: Nonresidential~~
Civic Meeting Space	Table 2-4: Nonresidential
Commercial and ~~/~~Industrial Storage	Table 2-4: Nonresidential
Convention, Conference, Multipurpose, and Meeting Centers	Table 2-4: Nonresidential
Corridors, Restrooms, Stairs, and Support Areas	Table 2-4: Nonresidential
Dining ~~Area~~	Table 2-4: Nonresidential
Electrical, ~~and~~ Mechanical Room	Table 2-4: Nonresidential
Exercise~~ing~~ Center, ~~s and~~ Gymnasium	Table 2-4: Nonresidential
Exhibit, ~~Display Area and~~ Museum	Table 2-4: Nonresidential
Financial Transaction	Table 2-4: Nonresidential
~~General Commercial and /Industrial Work, High Bay -General~~	~~Table 2-4: Nonresidential~~
~~General Commercial and Industrial Work, Low Bay~~	~~Table 2-4: Nonresidential~~
~~General Commercial and /Industrial Work, -Precision~~	~~Table 2-4: Nonresidential~~
Dry Cleaning (Coin Operated)	Table 2-4: Nonresidential
Dry Cleaning (Full Service Commercial)	Table 2-4: Nonresidential
General Commercial and Industrial Work, High Bay	Table 2-4: Nonresidential
General Commercial and Industrial Work, Low Bay	Table 2-4: Nonresidential
General Commercial and Industrial Work, Precision	Table 2-4: Nonresidential
Grocery Sales ~~Area~~	Table 2-4: Nonresidential
~~Housing, Public and Commons Areas, Multi-family without Setback Thermostat~~	~~Table 2-6: Residential / with Setback~~
~~Housing, Public and Commons Areas, Dormitory, Senior Housing without Setback Thermostat~~	~~Table 2-7: Residential / without Setback~~
High-rise Residential with Setback Thermostat	Table 2-6: Residential / with Setback
High-rise Residential without Setback Thermostat	Table 2-7: Residential / without Setback
Hotel Function Area	Table 2-5: Hotel Function
Hotel/Motel Guest Room with Setback Thermostat	Table 2-6: Residential / with Setback
Hotel/Motel Guest Room without Setback Thermostat	Table 2-7: Residential / without Setback
Housing, Public and Commons Areas, Multi-family with Setback Thermostat	Table 2-6: Residential / with Setback
Housing, Public and Commons Areas, Multi-family without Setback Thermostat	Table 2-7: Residential / without Setback
Housing, Public and Common Areas, Dormitory, Senior Housing with Setback Thermostat	Table 2-6: Residential / with Setback
Housing, Public and Commons Areas, Dormitory, Senior Housing without Setback Thermostat	Table 2-7: Residential / without Setback
Kitchen, ~~and~~ Food Preparation	Table 2-4: Nonresidential
Laundry	Table 2-4: Nonresidential
Library, ~~-~~ Reading Areas	Table 2-4: Nonresidential
Library, ~~-~~ Stacks	Table 2-4: Nonresidential

Occupancy or Sub-Occupancy Type	Schedule
Lobby,~~-~~ Hotel	Table 2-5: Hotel Function
Lobby,~~-~~ Main Entry ~~and Assembly~~	Table 2-4: Nonresidential
~~Lobby, - Office Reception/Waiting~~	~~Table 2-4: Nonresidential~~
Locker~~ and ~~/Dressing Room	Table 2-4: Nonresidential
Lounge, Recreation	Table 2-4: Nonresidential
Mall~~s,~~ ~~Mall, Arcade and Atrium~~	Table 2-7 Retail~~Table 2-4: Nonresidential~~
Medical and Clinical Care	Table 2-4: Nonresidential
Office	Table 2-4: Nonresidential
~~Parking Garage~~	~~Table 2-4: Nonresidential~~
Police Station and Fire Station	Table 2-4: Nonresidential
Religious Worship	Table 2-4: Nonresidential
Retail Merchandise Sales, ~~and~~ Wholesale Showroom	Table 2-8: Retail~~Table 2-4: Nonresidential~~
~~Smoking Lounge~~	~~Table 2-4: Nonresidential~~
Tenant Lease Space	Table 2-4: Nonresidential
~~Transportation Function~~	~~Table 2-4: Nonresidential~~
Theater, ~~(~~Motion Picture~~)~~	Table 2-4: Nonresidential
Theater, ~~(~~Performance~~)~~	Table 2-4: Nonresidential
Transportation Function	Table 2-4: Nonresidential
Waiting Area	Table 2-4: Nonresidential
All Other	Table 2-4: Nonresidential
~~Unknown~~	~~Table 2-4: Nonresidential~~

2.5.2.4. Standard Design Systems

Description: All ACMs ~~must~~ shall accept input for and be able to model the following system types for both the standard and proposed design:

- **System 1**: Packaged Single Zone (PSZ), Gas furnace and electric air conditioner constant volume and variable volume.
- **System 2**: Packaged Single Zone (PHP), Electric heat pump and air conditioner constant volume and variable volume..

~~FIGURE~~ TABLE N2-11~~2A~~ – SYSTEM #1 AND SYSTEM #2 DESCRIPTIONS

Supply Fan Control: Constant volume or variable volume, standard design is constant volume.

For variable volume, Individual VAV supply fan with ~~25~~ less than 10 horsepower ~~and less~~:

VAV - forward curved fan with discharge damper

For individual VAV supply fan greater than or equal to ten ~~25~~ horsepower:

VAV - variable speed drive

2.5.2.6 Equipment Performance of Air Conditioners and Heat Pumps without SEER Ratings~~Curves (except for electric chillers)~~

Description The four reference method performance curves specified here include.

HEAT-EIR-FT	Heating efficiency as a function of ~~ourdoor~~ outdoor dry bulb and return wet bulb temperatures.
HEAT-CAP-FT	Heating capacity as a function of outdoor dry bulb temperature and the return wet bulb temperature. This curve adjusts the capacity of the heat pump as the ODB changes. This is an important curve for heat pumps as an electric resistance element comes on to provide heat when the heat pump has inadequate capacity.
MAX-HP-SUPP-T	This parameter is the outside drybulb temperature below which the heat pump supplemental heating is allowed to operate. This parameter shall be set to 70 °F.

COOL-EIR-FT The COOL-EIR-FT curve adjusts the efficiency of the cooling equipment in response to the outdoor drybulb temperature and the wetbulb temperature of the air returning to the indoor coil.

Equation N2-1 $$\text{COOL-EIR-FT} = a + b \cdot EWB + c \cdot EWB^2 + d \cdot ODB + e \cdot ODB^2 + f \cdot EWB \cdot ODB$$

where:

T24-COOL-EIR-FT = Normalized cooling energy input ratio for Title 24 standards

EWB = Entering wet bulb temperature

ODB = Outdoor dry bulb temperature

a, b, c, d, e, f = Regression constants and coefficients

HEAT-EIR-FT ~~The HEAT-CAP-FT~~ This curve in the reference method adjusts the efficiency of the heating equipment in response to the outdoor drybulb temperature.

Equation N2-2 HEAT-EIR-FT = a + b * ODB + c * ODB^2 + d * ODB^3

where:

T24-HEAT-EIR-FT = Normalized heating energy input ratio for Title 24 standards

ODB = Outdoor dry bulb temperature

a, b, c, d = Regression constants and coefficients

HEAT-CAP-FT This curve adjusts the capacity of the heat pump in response to the outdoor drybulb temperature. This curve adjusts the capacity of the heat pump as the ODB changes. This is an important curve for heat pumps as an electric resistance element comes on to provide heat when the heat pump has inadequate capacity.

Equation N2-3 HEAT-CAP-FT = a + b * ODB + c * ODB^2 + d * ODB^3

where

HEAT-CAP-FT = Normalized heating capacity

ODB = Outdoor dry bulb temperature

a, b, c, d = Regression constants and coefficients

Default The default equipment performance curves coefficients are specified in Table N2-27.

Table N2-27 – Default Coefficients for COOL-CAP-FT, COOL-EIR-FT, HEAT-CAP-FT and HEAT-EIR-FT Equations

Coefficient	COOL-CAP-FT	COOL-EIR-FT	HEAT-CAP-FT	HEAT-EIR-FT
a	0.053815799	-0.4354605	0.253761	1.563358292
~~B~~ b	0.02044874	0.0499555	0.010435	0.013068685
~~C~~ c	-1.45568E-05	-0.0004849	0.000186	-0.001047325
~~D~~ d	-0.000891816	-0.011332	-1.50E-06	1.08867E-05
~~E~~ e	-1.22969E-05	0.00013441		
~~eF~~ f	-2.61616E-05	0.00002016		

2.5.2.7 ~~Cooling Efficiency~~ Equipment Performance of ~~DOE Covered~~ Air Conditioners with SEER Ratings and Heat Pumps with SEER and HSPF Ratings

Input ACMs shall require the user to enter the SEER (seasonal energy efficiency ratio). The user may also optionally enter the EER (energy efficiency ratio). ACMs shall require the user to enter the HSPF (heating seasonal performance factor). The user may also optionally enter the COP (coefficient of performance) at 47 F and the ACM may allow the user to enter COP 17 F. From these data the reference method determines equipment performance curves.

Proposed Design Modeling Assumptions The proposed design shall use the SEER and EER and HSPF of the equipment shown on the plans and included in the construction specifications. As an alternative to HSPF, the ACM shall allow the user to enter a COP at 47 F and may allow a user to enter a COP at 17 F. When a user enters HSPF but does not enter COP 47 F and COP 17 F, the ACM shall calculate the COP 47 F and COP 17 F as described for the Standard Design.

Standard Design Modeling Assumptions The standard design shall use performance curves based on the SEER of the equipment required by the Standards. The default EER, as defined below shall be used. The standard design heat pump shall have an HSPF as required by section 111. The COP at 47 F shall be determined as below. The efficiency at other outdoor temperatures shall be based on the default DOE-2 HEAT-EIR-FT curve.

For single package units and split systems: COP47 = HSPF * 0 28 + 1.13

The standard design shall determine the COP at other outside temperatures from the DOE 2 default curves.

HEAT-CAP-FT	This curve adjusts the capacity of the heat pump as the ODB changes. This is an important curve for heat pumps as an electric resistance element comes on to provide heat when the heat pump has inadequate capacity. HP-CAP-FT = CURVE-FIT TYPE = CUBIC DATA = (67,1.337) = (57,1.175) = (47,1.000) = (17, CAP_{17}/CAP_{47}) = (7, $0.702 \times CAP_{17}/CAP_{47}$) = (-13, 0.153)
MAX-HP-SUPP-T	This parameter is the outside drybulb temperature below which the heat pump supplemental heating is allowed to operate. This parameter shall be set to 70 °F.

2.5.3.8 Sizing Requirements

Sizing Procedure for System 2

Modeling Rules for ~~Reference~~ Standard Design (All):	3. Standard design heating capacity, $HCAP_{SS}$, is determined from the following procedure: e) The electric heating capacity for the standard design is thus determined: $HCAP_{selec} = 1.43 \times (HLOAD_{sdesign} - HCAP_{sdesign})$

VII. Glossary

Term	Definition
CONVENTION~~, CONFERENCE, MULTIPURPOSE AND MEETING~~ CENTERS	See *Occupancy Type*.
~~BANK/FINANCIAL INSTITUTION~~	~~See *Occupancy Type*.~~
CIVIC ~~FACILITY~~ MEETING SPACE	See *Occupancy Type*.
CLASSROOM, LECTURE, ~~OR~~ TRAINING, VOCATIONAL ROOM	See *Occupancy Type*.
~~COMMERCIAL AND INDUSTRIAL STORAGE:~~	~~See *Occupancy Type*.~~
VII.1 financial ~~INSTITUTION~~ transaction	VII.1.1 See Occupancy Type
VII.2 HOTEL LOBBY	VII.2.1 See Occupancy Type, Lobby, Hotel
INDUSTRIAL AND COMMERCIAL STORAGE BUILDINGS:	See *Occupancy Type*.
VII.3 main entry LOBBY ~~/RECEPTION/WAITING~~	VII.3.1 See Occupancy Type, lobby, Main Entry
VII.4 MALL BUILDING	**Is a single building enclosing a number of tenants and occupants wherein two or more tenants have a main entrance into one or more malls.**
~~VII.5 MULTI-FAMILY~~	***See Occupancy Type***
OCCUPANCY TYPE	is one of the following: **Civic ~~facility~~ meeting space** is a city council or board of supervisors meeting chamber, courtroom, or other official meeting space accessible to the public ~~or town hall, courthouse, public administration building, or public service building~~. **Malls~~, arcades and atria~~** is a roofed or covered common pedestrian area within a mall building that serves as ~~are public passageways or concourses that provides~~ for two or more tenants ~~to rows of stores or shops~~. ~~**Reception/waiting area** is an area where customers or~~

Term	Definition
	~~clients are greeted prior to conducting business.~~ ~~**Shopping center building** is a multiple tenant building intended to house retail and service type occupancies.~~ **Transportation ~~facilities~~ function** is the ticketing area, waiting area, baggage handling areas, concourse, or other areas not covered by primary functions in Table 146-C in an airport terminal, bus or rail terminal or station, subway or transit station, or a marine terminal.
VII.6 WAITING AREA	VII.6.1 See Occupancy Type

Building Energy Efficiency Standards, Section 101 (b)

OCCUPANCY TYPE is one of the following:

Civic meeting ~~place~~ space is a city council or board of supervisors meeting chamber, courtroom, or other official meeting space accessible to the public.

~~**Reception/waiting area** is an area where customers or clients are greeted prior to conducting business.~~

OUTDOOR LIGHTING CHANGES

147 (c) 2

E. Determine the allowed lighting power for lighting of uncovered vehicle service stations. The allowed lighting power for an uncovered service station shall be the smaller of the product of the allowed lighting power density for a vehicle service station with or without canopies and 500 ~~hundred~~ square feet per double-sided fuel dispenser, or the actual power (in cases where the site only allows fuel to be dispensed on one side of the dispenser, the allowed lighting power shall be the smaller of the product of the allowed lighting power density and 250 square feet per dispenser, or the actual power).